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POTOMAC RIVER WATER QUALITY, WASHINGTON, D.C. METROPOLITAN AREA

Federal Water Pollution Control Administration
Cincinnati, Ohio

1969

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POTOMAC RIVER WATER QUALITY

WASHINGTON, D.C. METROPOLITAN AREA

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
U. S. DEPARTMENT OF THE INTERIOR
1969

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Technical Advisory & Investigations Branch

Division of Technical Services

Cincinnati, Ohio

in cooperation with

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SUMMARY

This report reviews the status of water quality in the Potomac River estuary approximately one decade since a Federal Enforcement Conference was conducted on pollution of interstate waters of the Potomac River in the Washington Metropolitan Area. Sessions of the Conference were convened on August 22, 1957 and February 13, 1958.

The conferees, representing the Federal Government, the District of Columbia, and the states of Maryland and Virginia, recommended that:

1. The District of Columbia accomplish by 1958 disinfection of sewage when necessary and 80 percent reduction of biochemical oxygen demand (BOD) in sewage reaching the treatment plant, that that degree of reduction be maintained, and that plans for additional treatment as needed be made far enough in advance so that the District plant would not again become a significant source of pollution to the Potomac River.

2. The Virginia communities (Alexandria, Arlington, and Fairfax County) provide treatment commensurate with that of the District.

3. The District implement, by 1966, the recommendations of their consulting Board of Engineers (Plan C - except for the Rock Creek interceptor) for control of stormwater overflows.

Six of the nine major sewage treatment plants met the recommendations of the conferees that 80 percent BOD removal be accomplished. The District of Columbia (71.2 percent), Alexandria, Virginia (76.2 percent), and Fairfax County, Virginia's Westgate Plant (49.8 percent) failed to meet the conferees' recommendations. These three plants currently account for 94 percent of the BOD load discharged to the Potomac River.

Effective disinfection of treated discharges, as recommended by the conferees, was not accomplished.

The District has made commendable progress in implementation of a revised Plan C for control of raw sewage discharges, but the recommended schedule of completion by 1966 was not met. Control of 39.6 percent of the raw sewage discharge has been accomplished and another 38.3 percent is now scheduled for control by 1969. Separation of the combined storm and sanitary sewers in progress that accounted for 22.1 percent of the total discharge is not scheduled for completion before the year 2000.

Despite the advances, the Potomac River Estuary in the Washington Metropolitan Area remains grossly polluted due to inadequate sewage treatment, the rapid population growth, and the discharge of combined sewer overflows and raw sewage.

Extremely high densities of bacteria from sewage posed a threat to the health of all those who came in contact with the water of the river.

Decomposing organic matter in the water and sewage sludge deposits on the bottom of the river reduced the dissolved oxygen (DO) content of the river to levels that would not support a sport fishery. Near the point of the District of Columbia treatment plant discharge, the DO has been so low that it would not support even the most tolerant pollution-resistant rough fish, such as carp and catfish.

Clean-water bottom organisms that serve as food for fish have been replaced by pollution-tolerant forms that are not suitable for fish. The sludge deposits have blanketed fish spawning grounds and destroyed the bottom aquatic life on which fish feed. In areas along the margins of the estuary, sludge deposits released obnoxious odors when uncovered at ebb tide. Floating sludge masses, lifted by gasses of decomposition, added to other debris on the water's surface.

Repulsive debris, including solid materials from raw sewage, defiled the surface of the estuary in the vicinity of combined sewer overflows during and following periods of rainfall. These overflows also contributed to bottom deposits, high bacterial densities, and low DO concentrations.

Nutrients from upstream sources added to those in sewage treatment plant discharges to the estuary supported excessive growths of algae. These minute suspended plants may turn the water green, add to DO depletion problems and cause fish kills and offensive odors. The filamentous forms may litter bathing waters and beaches with slimy masses and also produce obnoxious odors. Special treatment to reduce phosphorus in sewage plant effluents can control excessive algal growths.

Silt from both upstream and the urban area was a major problem. The clarity of the water was intermittently diminished, reducing the scenic

attractiveness of the river. Fish spawning grounds and fish food bottom aquatic organisms have been destroyed. It has been calculated that the 60,000,000 cubic feet (2,500,000 tons) of silt reaching the Potomac estuary annually could fill the estuary to the surface from Chain Bridge to Fort Foote in 50 years. A basin-wide cooperative program would be necessary for control of silt pollution. A program that would reduce silt reaching the estuary by 45 percent at an estimated cost of $250,000,000 has been recommended.

Storm water drainage and raw sewage overflows and leakage from adjacent sewers to Rock Creek caused bacterial pollution that was a hazard to the health of those who came in contact with the water, and have destroyed much of the aesthetic appeal of this stream that should be one of the major attractions of the National Park through which it flows.

The Anacostia River had much in common with Rock Creek. The sources of its pollution were similar. To the problems of excessive bacterial pollution and loss of aesthetic appeal that occurred in Rock Creek, the Anacostia has added that of extremely low DO.

Since the last session of the Enforcement Conference, the Federal requirement for water quality standards on interstate streams has been established. The Maryland standards for the Potomac River and Rock Creek have been approved by the Secretary of the Interior. The District of Columbia standards have been approved, but with exceptions on certain constituents.

Pollution of the Potomac River violates the Maryland standards in several ways.

1. Estimated fecal coliform bacterial densities are far in excess of the standard limit of 240 per 100 ml.

2. The average DO of 2.8 mg/l is well below the standard of 5.0 mg/l and the minimum DO of 0.4 is even further below the standard of 4.0 mg/l.

3. Substances from sewage have settled to form sludge deposits that are "unsightly, putrescent or odorous to such a degree as to create a nuisance, or that interfere directly or indirectly with water uses."

4. Floating debris and other materials from sewage have been "unsightly to such a degree as to create a nuisance, or interfere directly or indirectly with water uses."

5. Deleterious substances from sewage have been "harmful to . . . aquatic life."

Sewage treatment plants in the metropolitan area that have been responsible for pollution of the interstate waters of the estuary include those of:

*District of Columbia
Alexandria, Va.
Arlington County, Va.
Fairfax Co., Va. (Little Hunting Creek, Westgate, Dogue Creek)
Fort Belvoir (Federal)
Pentagon (Federal)

Also contributing to the pollution of the estuary have been combined sewer overflows from the District of Columbia and Alexandria, and raw sewage bypassed in the District of Columbia.

****

Waste discharges from the District of Columbia and Virginia cause pollution of the interstate waters of the Potomac River which endangers health or welfare of persons living in Maryland, Virginia and the District of Columbia, and therefore is subject to abatement under the provisions of the Federal Water Pollution Control Act.

Pollution discharged to Rock Creek and the Anacostia River in Maryland causes pollution of the interstate waters of Rock Creek and the Anacostia River which endangers the health and/or welfare of persons in the District of Columbia, and therefore is subject to abatement under the provisions of the Federal Water Pollution Control Act.

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* The District of Columbia Water Pollution Control Plant receives wastes from 340 square miles of Prince Georges and Montgomery counties in Maryland with a population of 876,000 and 100 square miles in Virginia with a population of 82,000 in addition to the 60 square miles in the District with a population of 810,000.

RECOMMENDATIONS

To meet Federal and State standards and to enhance water quality in the Potomac River estuary in the Washington, D.C. area, it is recommended that:

1. Waste treatment facilities be provided and maintained to ensure compliance with water quality standards. Meeting these standards at *present waste loads and discharge locations* requires a 98 percent reduction in raw sewage fecal coliform densities, and a 96 percent reduction in 5-day 20 degree C. BOD_5, with a maximum total discharge of 16,500 lbs/day BOD_5.

2. Phosphorus reduction facilities be provided for all wastes discharged to the Potomac estuary to prevent excessive algal growths. Meeting this recommendation at *present waste loads and discharge locations* requires a 96 percent reduction in total phosphorus (P) from all sources.

3. An evaluation be made of the feasibility of discharging effluent from the District of Columbia Water Pollution Control Plant through several outlets along the estuary rather than through the existing single outfall. Water quality advantages of multiple outlets should be assessed because these may indicate that reductions are possible in the extremely high removal percentages that are otherwise necessary for specific waste constituents. Before discharge all wastes must receive the highest degree of treatment practical, including phosphorus removal.

As waste loads increase, the degree of treatment provided by all plants must be such that the quality of the receiving waters, including the estuary and the tributaries thereto, is maintained within the requirements of the applicable standards.

4. Completion of the District of Columbia's revised Plan C for the elimination of combined sewer overflows and raw sewage diversion to the Potomac and Anacostia Rivers and Rock Creek be achieved as rapidly as feasible, with especial reference to advancement of the completion date insofar as possible for eliminating raw sewage discharges.

The State of Maryland take action to eliminate the pollution entering Rock Creek and the Anacostia River upstream from the Maryland-District of Columbia line.

Alexandria, Virginia, undertake a program commensurate with that of the District of Columbia for control of raw sewage discharges through combined sewer overflows and diversions.

5. Existing local, municipal, county, state, interstate, and Federal agencies involved in erosion and silt control unite in an expanded, coordinated effort to implement the 10-year accelerated silt control program for the Potomac River Basin including the Anacostia River and Rock Creek that was recommended by the Sedimentation and Erosion Sub-Task Force.

Seneca Dam and Reservoir site be preserved at its present level of economic development in accordance with the recommendation of the Potomac River Basin Advisory Committee and the Federal Interdepartmental Task Force in their "Potomac Interim Report to the President."

6. A systematic program be developed and conducted to prevent the disposal of trash, debris, junk, and other objectionable material adjacent to and into waterways. "Operation Clean Waters," a cooperative effort between the government of the District of Columbia and the Federal Government utilizing enrollees of the Neighborhood Youth Corps, is an example of the type of cooperative program needed.

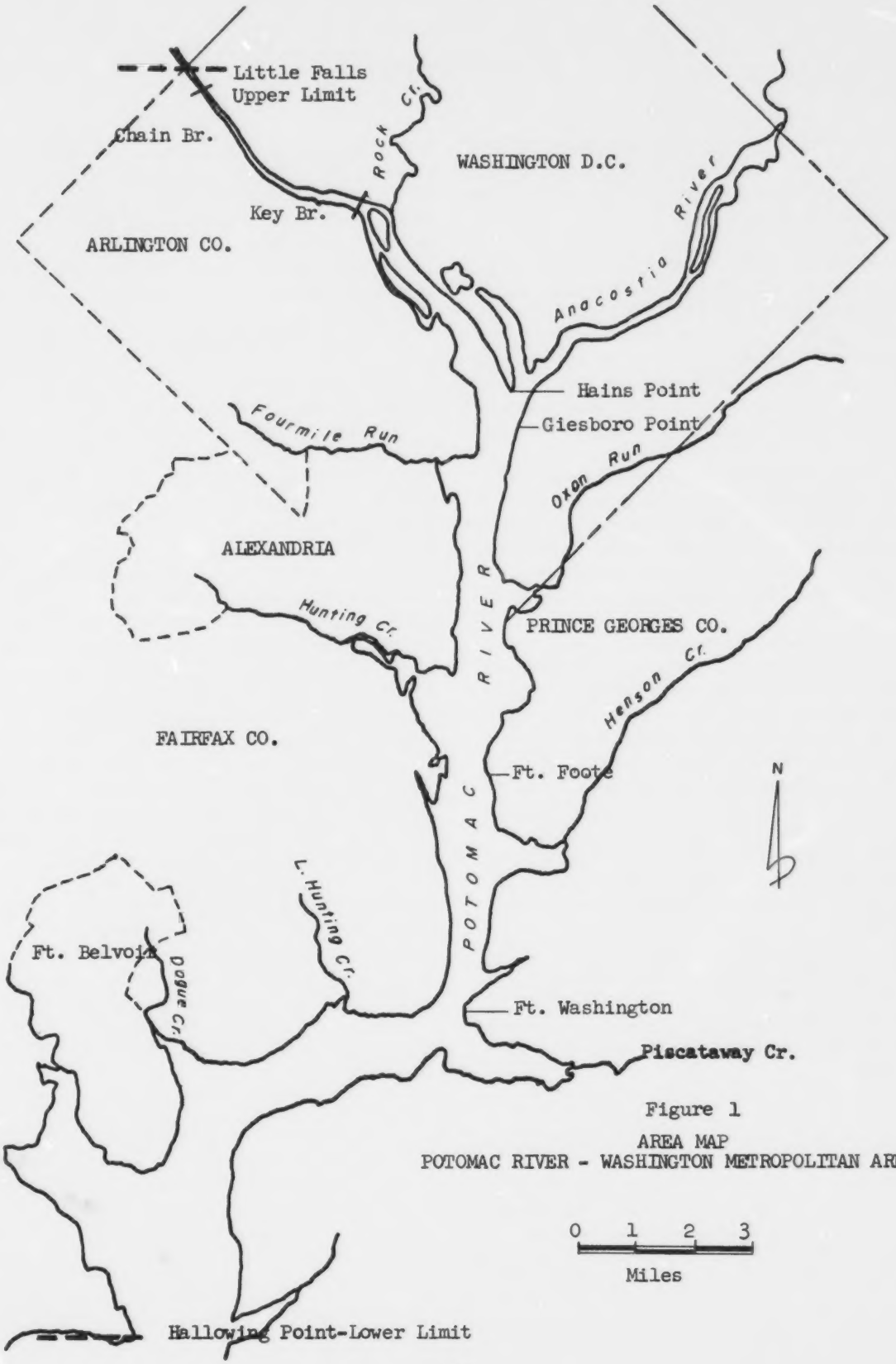


Figure 1

AREA MAP
POTOMAC RIVER - WASHINGTON METROPOLITAN AREA

On August 22, 1957 the Surgeon General of the U.S. Public Health Service, Department of Health, Education and Welfare, who at that time was responsible for the Federal Water Pollution Control Program, called a Conference on pollution of interstate waters of the Potomac River in the Washington Metropolitan Area (District of Columbia, Maryland, Virginia) (Figure 1). A second session of the Conference was convened on February 13, 1958.

This initiation of Federal enforcement action was the culmination of nearly a half century of Public Health Service interest in and concern over pollution of the Potomac in the metropolitan area.

The interest started with a comprehensive study of the effects on the river of the raw sewage from 320,000 persons in 1913-1914, and mild concern was expressed, in the conclusions of the subsequent report, that "the capacity of the river to dispose of (raw) sewage without nuisance or danger will eventually be overtaxed" and in the recommendation that "primary treatment works should be installed in the near future" by the District of Columbia for "the example in such matters that should be afforded by the national capital."

As the sewered population increased, mounting concern was reflected in subsequent Public Health Service reports issued at approximately ten-year intervals. In 1925, it was concluded that no section of the river adjacent to the District of Columbia "could be considered free enough from pollution with sewage to permit its use for bathing without a potential danger to such bathers of contracting sewage-borne diseases." Primary treatment or extension of an intercepting sewer downstream was recommended.

In 1932, with raw sewage from 575,000 persons pouring into the Potomac, the resulting pollution was described as critical. Bacterial pollution rendered the river unsuitable for bathing from Three Sisters Island to Fort Washington, a distance of 14 miles. Fish were endangered by reduction of dissolved oxygen concentrations to less than one-half their natural values in the four and one half miles between Giesboro Point and Fort Foote. Primary treatment again was recommended, but it was suggested that the plant design incorporate provisions for subsequent addition of secondary treatment. Action by the major polluter, the District of Columbia, followed the report, and five years later a primary treatment plant was placed in operation. During the 1930's smaller Maryland and Virginia communities in the Washington Metropolitan Area also completed treatment plants.

The primary treatment plants were designed to remove only about one-third of the oxygen-demanding organic matter. By 1943, when the 1,149,000 sewered population of the metropolitan area was double that of 1932, the Potomac was receiving an organic load that was one-third greater than it had been in 1932, before any treatment was provided. The treated effluents from all treatment plants carried a combined organic load equivalent to that in the raw sewage from 781,000 persons (population equivalent, or P.E.). The 1944 report recommended that secondary treatment be provided.

By the time of the 1957 session of the Conference the sewered P.E. of the metropolitan area had increased to 1,678,000, or 46 percent over that of 1943. There was an equivalent increase in P.E. of the treated sewage to 1,143,000. Thus, the treated sewage in 1957 had a P. E. very nearly twice that in 1932 when there was no treatment. Of this load, 82.8 percent was contributed by the District of Columbia Blue Plains Sewage Treatment Plant, which received the sewage from the Maryland Suburban Sanitary District as well as that from the District. Federal installations with their own sewage treatment plants, the Pentagon and Ft. Belvoir, contributed 1.6 percent of the total load. Three Virginia jurisidctions, Arlington and Fairfax counties and Alexandria, accounted for the remaining 15.6 percent. In addition to the treated sewage the Potomac River received discharges of undetermined quantities of raw sewage, both directly and by way of tributaries such as Rock Creek and Anacostia River, from combined sewers, overloaded interceptors, and pumping station and treatment plant bypasses.

The ever-increasing sewage load inevitably resulted in increasing degradation of water quality in the Potomac. Bacterial contamination that rendered the water hazardous to the health of bathers and others coming in contact with the water extended at least from Three Sisters Island to Hallowing Point, a distance of 22.4 miles.

Sampling and laboratory analysis by District of Columbia treatment plant personnel that provided the data for the 1957 report did not extend beyond Hallowing Point, and it cannot be determined how much farther downstream excessive bacterial densities persisted. Excessive DO depletion, hazardous to fish and other aquatic life, extended from the Twin Highway Bridge at least to Hallowing Point, a distance of 19.0 miles. Obnoxious floating solids from raw sewage overflows or bypasses destroyed the natural beauty of extensive areas of the river's surface. Foul odors emphasized the occurrence of pollution in the vicinity of overflows and bypasses, especially near the Lincoln Memorial and along the Washington Channel and the Anacostia River.

The District of Columbia already had completed plans for extension of its sewage treatment plant at the time of the Conference. The conclusions and recommendations as agreed to by the conferees and included in the Conference Summary issued by the Surgeon General on April 4, 1958 are as follows:

1. That cognizance is taken of the work done by the official water pollution control agencies of the District of Columbia, Maryland, and Virginia and the Interstate Commission on the Potomac River Basin in recognizing, analyzing, and acting to secure abatement of pollution of the interstate waters of the Potomac River - Washington Metropolitan Area;

2. That cognizance is taken of the remedial facilities installed by the District of Columbia, Maryland and Virginia political subdivisions to abate such pollution;

3. That the District of Columbia will provide secondary treatment (including chlorination of the effluent when necessary) at its Blue Plains plant by 1958 that will remove 80 percent of the waste load going through that plant as measured by BOD;

4. That the District of Columbia will make further improvements to the Blue Plains plant which will be completed by 1965. These improvements will provide full secondary treatment which will result in the continued removal of 80 precent of the wastes going through the plant as measured by BOD;

5. That the District of Columbia make plans sufficiently in advance so that additional construction which may be necessary beyond that contemplated to be completed by 1965 will be accomplished so that discharges from the Blue Plains plant will not again become a significant source of pollution of the Potomac River (Washington Metropolitan Area);

6. That the District of Columbia, in order to reduce pollution of the Potomac River (Washington Metropolitan Area) from storm water overflows, put into effect Plan C (except the Rock Creek interceptor) as proposed by the Board of Engineers in its "Report to District of Columbia Department of Sanitary Engineering on Improvements to Sewage System" dated February 28, 1957; and that the construction of these remedial facilities by completed by the end of 1966; and appropriate financial arrangements be made to accomplish this;

7. That the Virginia communities in the Washington Metropolitan Area will provide treatment commensurate with those provided by the District of Columbia and Maryland political subdivisions;

8. That processes be initiated to define what responsibility the Federal Government should have in the program to abate pollution of the Potomac River in the Washington Metropolitan Area;

9. That the official State water pollution control agencies of the District of Columbia, Maryland, Virginia, and the Interstate Commission on the Potomac River Basin cooperate with each other in the provision and exchange of information on a continuous sampling program of the quality of water of the Potomac (Washington Metropolitan Area); and

10. That the Public Health Service will report to the other conferees as to progress at six-month intervals.

WATER USES

Water uses are essentially the same as they were in 1957, but there have been increases in numbers of those using the Potomac as the metropolitan population has increased.

The water supply intakes for the Washington Metropolitan Area are some distance upstream from Little Falls, the upper limit of the Potomac considered in this report. The water is returned as treated and untreated sewage, to be carried away by the river.

Throughout the 26-mile reach under consideration (Figure 1), from Little Falls to Hallowing Point, recreation is a major use of the river. Pleasure boating is predominant, and water skiing, swimming and fishing are popular pastimes. Many of the area's beautiful parks border the Potomac and Anacostia rivers and Rock Creek. Thousands of residents and both national and international visitors enjoy the scenic beauty of these waters daily in the parks, from other vantage points, and in passing.

Navigation is an important use of the Potomac River and the lower Anacostia. Those engaged in navigation, its attendant activity, channel maintenance and other work on the streams come into both direct and indirect contact with the waters.

The principal industrial use of the Potomac River water is for cooling processes.

WATER SOURCES

Sewage treatment plant effluents are the principal wastes that affect the quality of Potomac River water. The river and tributary streams, including Rock Creek and Anacostia River, intermittently receive variable waste discharges, including sewage from combined sewers, overloaded interceptors and bypasses, and washings from storm water runoff.

Treated Sewage

Operating records of the sewage treatment plants in the area were furnished by the various sewer departments, and provide the basis for the following discussion. Nine plants in the area treat sewage with an oxygen demand P.E. of 2,456,000 (Table 1 and Figure 2), a 46.4 percent increase since 1957. The treated sewage has a combined P.E. of 673,900 for a reduction since 1957 of 41.0 percent in the organic load discharged to the river by the treatment plants. This P.E. is 17.2 percent greater than it was in 1932 before any treatment was provided.

Figure 3 shows the increase in sewered population from 1913 to 1967, together with the corresponding P.E. of the treated sewage. The first downward trend in the organic load discharged to the Potomac since this series of reports on Potomac River pollution started is attributable principally to improved treatment by the District of Columbia Water Pollution Control Plant (formerly the District of Columbia Blue Plains Sewage Treatment Plant).

In addition to receiving sewage from the District, the District of Columbia Water Pollution Control Plant accepts sewage from the Washington Suburban Sanitary Commission, several governmental bodies in Virginia, and several Federal agencies. This is done under agreements between the District and the agencies concerned. Payment to the District of Columbia is based on the cost of construction and maintenance of sewers and the cost of treating the sewage contributed. The WSSC operates the plant located on Piscataway Creek. The Federal Government operates treatment plants at the Pentagon and Fort Belvoir. Three jurisdictions in Virginia operate five plants. Alexandria and Arlington County are responsible for one each, and Fairfax County for three, the Westgate, Little Hunting Creek and Dogue Creek plants. The Fairfax County sewage formerly treated in its Pimmit Run plant is now conveyed across the river into the District of Columbia sewerage system. The points of effluent discharge and the relative organic loads in the various discharges are shown in Table 1 and Figure 4. The District of Columbia plant contributed 75.8 percent of the total load. The five Virginia plants accounted for 22.5 percent, the WSSC Piscataway plant for 1.1 percent, and the two Federal plants for 1.0 percent.

Table 2 includes data on suspended solids in the raw and treated sewage of the nine treatment plants. The combined suspended solids load of 531,400 pounds per day was reduced 73.8 percent to 138,900 pounds per day. In a year's time the Potomac received more than 25,000 tons

Table 1

SOURCES OF SEWAGE DISCHARGED TO THE POTOMAC RIVER
IN THE WASHINGTON, D. C. METROPOLITAN AREA
Oxygen Demand

Source	Discharge Location	BOD, lbs/day (1) (5 day, 20° C)			Population (2) Equivalent		Percent of total sewage load to the Potomac River	
		Influent	Effluent	% Removed	Influent	Effluent	Influent P.E.	Effluent P.E.
Alexandria, Va.	Hunting Creek	40,000	9,500	76.2	222,220	52,780	9.1	7.8
Arlington Co., Va.	Fourmile Run	36,000	3,600	90.0	200,000	20,000	8.1	3.0
Fairfax Co., Va.								
Westgate	Hunting Creek	25,100	12,600	49.8	139,440	70,000		
Little Hunting Creek	Little Hunting Creek	5,100	1,000	80.4	28,330	5,560		
Dogue Creek	Dogue Creek	3,100	600	80.6	17,220	3,330		
Total Fairfax Co.		33,300	14,200		184,990	78,890	7.5	11.7
District of Columbia	Potomac River	320,000	92,000	71.2	1,777,800	511,100	72.4	75.8
Pentagon	Boundary Channel	1,440	240	83.3	8,000	1,330	0.3	0.2
Ft. Belvoir	Dogue Creek	2,910(3)	470(3)	84.0	16,170	2,610	0.7	0.4
Washington Suburban Sanitary District – Piscataway Plant	Piscataway Creek	8,500	1,300	84.7	47,220	7,220	1.9	1.1
Total		442,150	121,310	72.6	2,456,400	673,930	100.0	100.0

Notes:
(1) Based on Plant Records–most current available
(2) Based on 0.18 lb. BOD per capita for comparison with 1957 report
(3) Estimated

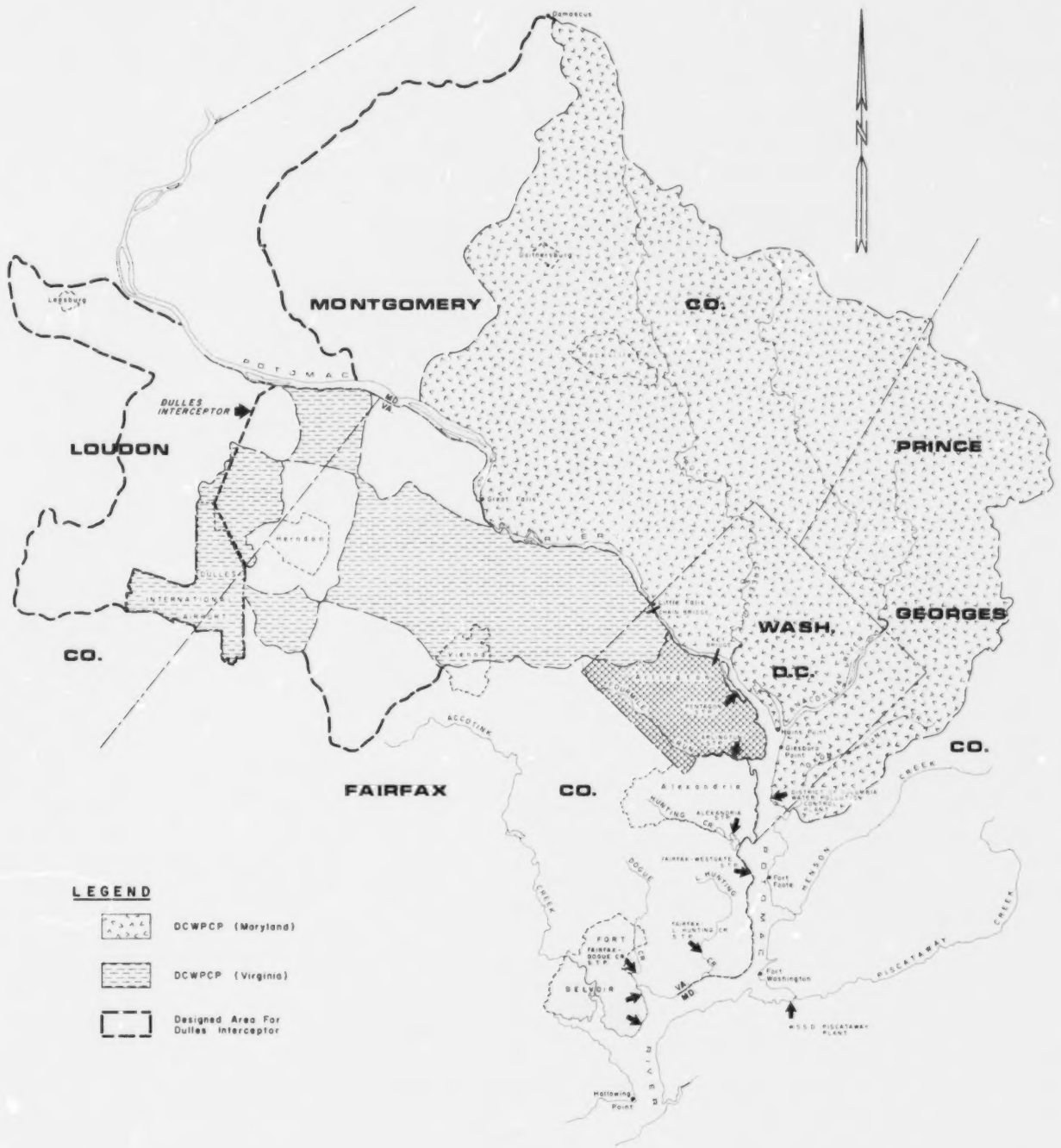
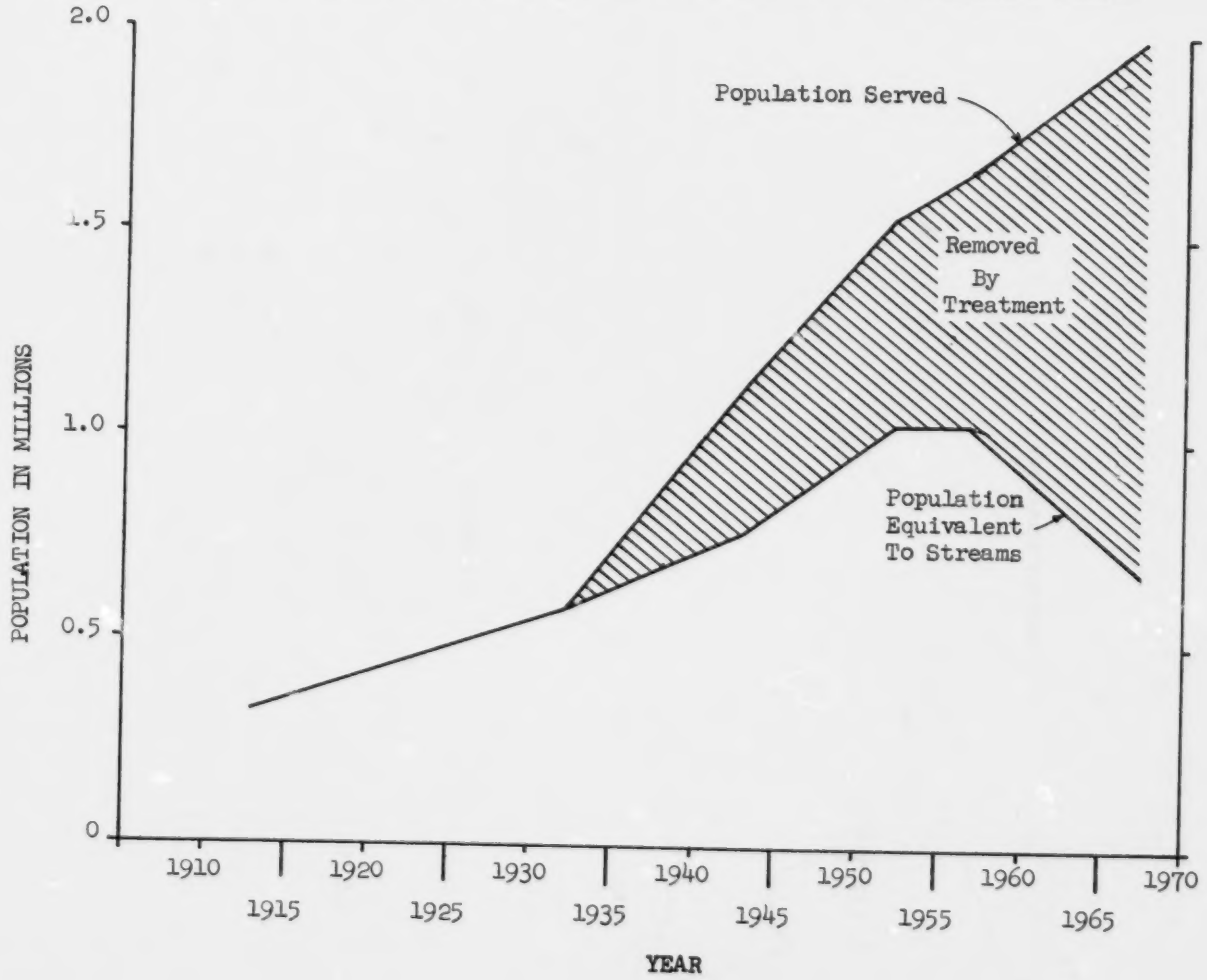


FIGURE 2

MAJOR WASTE SOURCES
POTOMAC RIVER - WASHINGTON METROPOLITAN AREA

Figure 3

POTOMAC RIVER WASHINGTON METROPOLITAN AREA
TRENDS IN POPULATIONS CONTRIBUTING SEWAGE TO RECEIVING WATERS



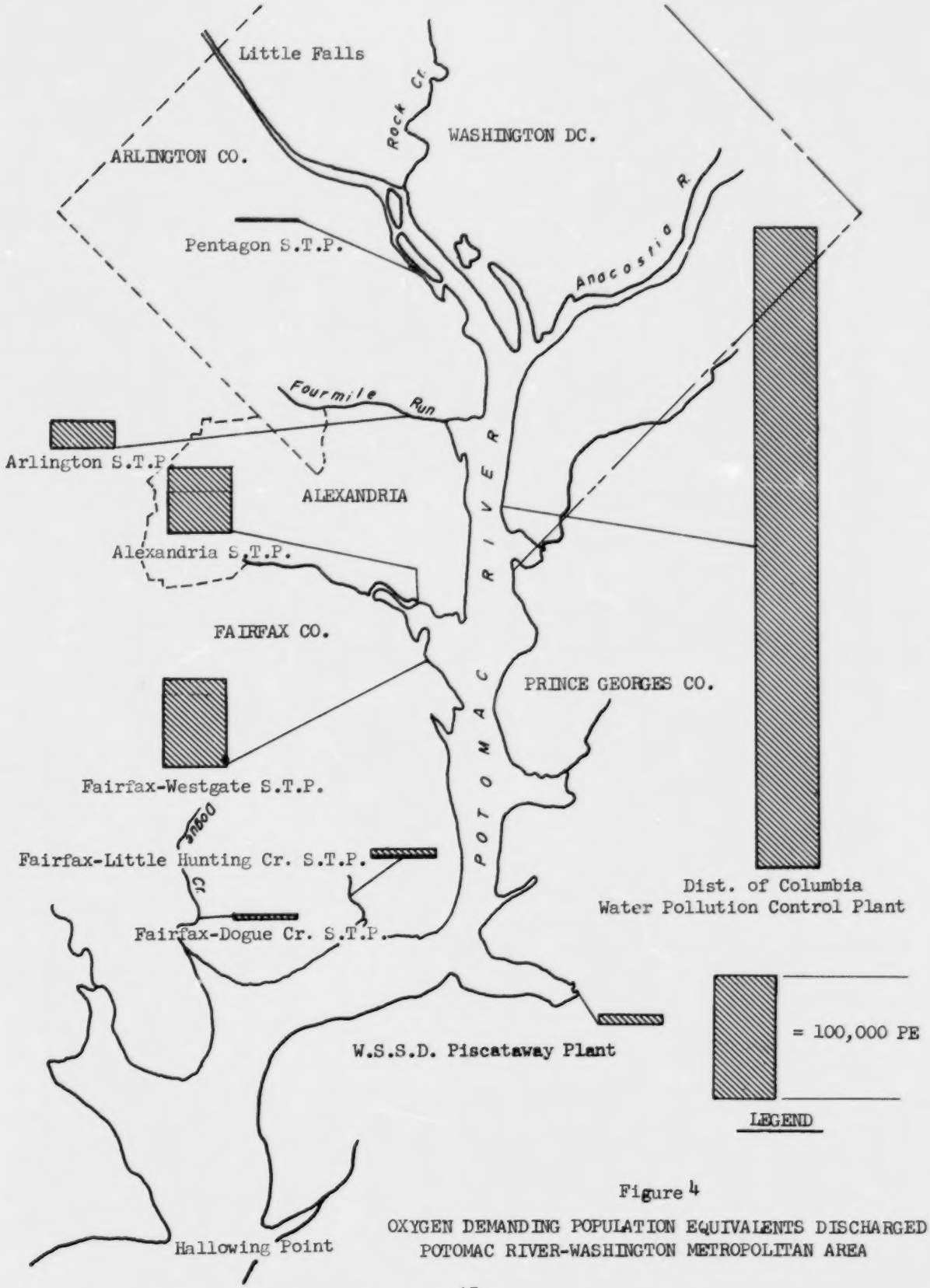


Figure 4

OXYGEN DEMANDING POPULATION EQUIVALENTS DISCHARGED
POTOMAC RIVER-WASHINGTON METROPOLITAN AREA

Table 2

SOURCES OF SEWAGE DISCHARGED TO THE POTOMAC RIVER
IN THE WASHINGTON, D. C. METROPOLITAN AREA
Suspended Solids

Source	Discharge Location	Suspended Solids(1) lbs/day			Population(2) Equivalents		Percent of total sewage load to the Potomac River	
		Influent	Effluent	% Removed	Influent	Effluent	Influent P.E.	Effluent P.E.
Alexandria, Va.	Hunting Creek	36,000	9,600	73.3	180,000	48,000	6.7	6.9
Arlington Co., Va.	Fourmile Run	44,000	3,800	91.4	220,000	19,000	8.3	2.7
Fairfax Co., Va. Plants								
Westgate	Hunting Creek	22,000	10,000	54.5	110,000	50,000		
Little Hunting Creek	Little Hunting Creek	4,200	900	78.6	21,000	4,500		
Dogue Creek	Dogue Creek	2,400	700	70.8	12,000	3,500		
Total Fairfax Co.		28,600	11,600		143,000	58,000	5.4	8.4
District of Columbia		408,000	112,000	72.5	2,040,000	560,000	76.8	80.6
Pentagon	Boundary Channel	1,600	340	78.8	8,000	1,700	0.3	0.2
Ft. Belvoir	Dogue Creek	3,200(3)	485(3)	85.0	16,170	2,430	0.6	0.4
Washington Suburban Sanitary District – Piscataway Plant	Piscataway Creek	10,000	1,100	89.0	50,000	5,500	1.9	0.8
Totals		531,400	138,925	73.8	2,657,170	694,630	100.0	100.0

Notes:
(1) Based on Plant Records–most current available
(2) Based on 0.2 lb suspended solids per capita per day
(3) Estimated

of suspended solids in the combined plant effluents. Of this, 80.6 percent was from the District of Columbia plant, 18.0 percent was from the five Virginia plants, 0.8 percent from the WSSC plant, and 0.6 percent was from the Pentagon and Fort Belvoir plants.

Raw sewage contains tremendous numbers of bacteria and other organisms, some of which are pathogenic. Even after conventional treatment, unless the effluent is disinfected, hazardous quantities of pathogenic organisms may be discharged from sewage treatment plants. Although data are not available either on reductions of bacteria by existing treatment or on numbers in the effluents of the Washington Metropolitan Area plants, bacteriological data on the river reveal that control of bacteria was inadequate to prevent serious hazards to the health of those who came in contact with the water.

Phosphorus is an essential nutrient for the growth of aquatic plants. In the reach of the Potomac considered, excessive aquatic plant growth is one of the adverse effects of pollution. Data on the quantities of phosphorus in the sewage can be estimated on the basis of sewered populations. The total phosphorus (as P) in waste sources prior to treatment was estimated to be 21,100 pounds per day. Reductions are less than 20 percent by the sewage treatment plants currently utilized in the metropolitan area. Data on phosphorus in the Potomac River show that there was far more than the minimum necessary to support excessive aquatic plant growths.

Status of Compliance with Conferees' Recommendations

The District of Columbia plant reduced the raw sewage BOD 71.2 percent (Table 1) compared to the 25 percent reduction accomplished in 1957. This was a worthwhile improvement, but was still less than the 80 precent reduction recommended by the conferees in February 1958.

Plants that accomplished improved percentage reductions since 1957 are:

Source	1957 Effluent Loads		Current Effluent Loads	
	P.E. Discharged	% Removal Efficiency	P.E. Discharged	% Removal Efficiency
District of Columbia	946,020	25.0	511,100	71.2
Alexandria, Va.	38,610	64.0	52,780	76.2
Fairfax Co., Va.				
Little Hunting Cr.	2,540	35.0	5,560	80.4
Dogue Creek	1,460	35.0	3,330	80.6
Fort Belvoir, Va.	16,000(1)	30.0(1)	2,610(1)	84.0(1)
Arlington Co., Va.	103,070	42.2	20,000	90.0(1)

(1)Estimated

Two plants failed to equal the reductions of 1957:

Source	1957 Effluent Loads		Current Effluent Loads	
	P.E. Discharged	% Removal Efficiency	P.E. Discharged	% Removal Efficiency
Pentagon	1,820	89.5	1,330	83.3
Fairfax Co.–Westgate	32,140	55.9	70,000	49.8

The WSSC Piscataway plant was not in operation in 1957.

The organic load to the river increased from four of the eight plants that were in operation in 1957 and at present. The Arlington County, District of Columbia, Pentagon and Fort Belvoir plants had reductions in their organic effluent loads when compared to 1957.

Six of the nine plants accomplished the 80 percent reduction recommended for the District of Columbia by the conferees. The Alexandria and District plants approached compliance with the recommendations at 76.2 and 71.2 percent, respectively. The Westgate plant of Fairfax County (48.9 percent) failed to provide treatment "commensurate with those provided by the District of Columbia and Maryland political subdivisions" (71.2 percent) as recommended by the conferees for the Virginia plants. If all plants had accomplished the recommended 80 percent reduction, the combined P.E. of all effluents would have been 491,000, or 73 percent of the 673,900 P.E. being discharged. The combined reduction by all plants was 72.6 percent compared to 32 percent in 1957, a commendable improvement though short of the required reduction.

The conferees also recommended chlorination of effluents "when necessary." The bacterial densities of the Potomac, reported subsequently, clearly demonstrated the immediate necessity of chlorination of sewage effluents for protection against hazards of waterborne diseases of all who come in contact with the water in the river. The stream data clearly demonstrate, also, that effective disinfection of effluents was not being practiced.

Raw Sewage

Raw sewage was discharged to the streams of the area in several different ways. Sewage pumping stations and treatment plants normally are equipped with bypasses to prevent hydraulic overloading or flooding of these facilities following rainfall and increased sewage flows. Sewage interceptors are equipped with overflow devices that operate when peak flows exceed their hydraulic capacities. Combined sewers, carrying both sewage and storm water, are provided with overflow devices that operate during and following rain storms when the combined flow exceeds the design capacity. Such diversions to the streams are for the prevention of the hydraulic overloading of the sewerage facilities. Portions of the sewer systems of the District of Columbia and Alexandria consist of combined sewers.

The total quantity of raw sewage that reached the streams of the area from all sources is not know, but a report for the District of Columbia by its Board of Consultants provided estimates of combined sewer overflows for the District's system. Estimates of overflows from overloaded interceptors were made by District of Columbia personnel. Since the District sewage comprised nearly three-quarters of this area's total, these estimates covered a major portion of the area's total raw sewage discharge.

The estimated annual discharge of raw sewage from the District system to the Potomac and Anacostia Rivers and Rock Creek was 5.222 billion gallons per year (Table 3) in 1960 when a program to reduce such discharges was initiated. About 4 billion gallons per year, or 11 million gallons per day (mgd), of this was continuous dry weather

flow from the Anacostia and Rock Creek main interceptors. The estimated P.E. of this discharge was 74,000. The remaining 1.222 billion gallons per year, or about one fourth of the total, was intermittent combined sewage overflow to the three streams. Although this averaged 3.3 mgd for the year, actually there were days, during dry weather, when there was little or no overflow and others, during and following rains, when the discharge rate was many times this average.

In the absence of a more direct estimate of combined sewer overflow from Alexandria, it may be assumed that the discharge from that community would be in proportion to that of the District of Columbia, adjusted for the relative populations served by the respective combined sewer systems. On this basis the Alexandria overflow would have been about 86 million gallons per year, or an average of 0.24 mgd, for an estimated P.E. of 2,100.

Rock Creek, flowing through beautiful Rock Creek Park, received intermittent overflows of raw sewage from the overloaded Rock Creek Main Interceptor and from combined sewers following rains. It also received raw sewage from defective or broken sewers and surface runoff from both rural and urban areas. Wastes reached the creek from the National Zoological Park. Two hundred and eleven separate sewer outlets had been identified as potential conveyors of sewage or surface runoff to the creek

The Anacostia River received overflows from combined sewers, as well as surface runoff and wastes from several industries.

Status of Compliance with Conferees' Recommendations

The District of Columbia is conducting a commendable program designed to collect raw sewage discharges for treatment (Table 3). Since the program started in 1960 nearly 40 percent of the raw sewage discharges have been eliminated. Most of this (2 billion gallons per year) was overflow of Washington Suburban Sanitary District sewage to the Anacostia River from the overloaded Anacostia River Main Interceptor at Blaine Street. The remainder was combined sewer overflow, eliminated by closure of 14 overflow points.

Construction currently underway and scheduled for completion in 1969 will eliminate overflow from the Rock Creek Main Interceptor and other combined sewer overflows. This will reduce the raw sewage discharge by another two billion gallons per year, a 78 percent reduction since 1960. Plans have been made to provide treatment of the wastes from the Zoological Park presently discharging to Rock Creek.

The remaining 22 percent of the 1960 raw overflow is principally from combined sewers. A program of sewer separation is underway, but must be carried out at a pace that will not cause either excessive financial burden or unreasonable disruption of traffic, and is not planned for completion before the year 2000. In the meantime, there is a continuing program of separating combined building plumbing. Separate system sewers and sewer relief projects in general are being constructed in advance of scheduled highway, street paving and urban renewal programs. These preliminary measures will facilitate future sewer separation by reducing traffic disruption and avoiding costly highway and street excavation.

The present 300 mgd peak capacity of the District of Columbia Water Pollution Control Plant will be increased to 528 mgd to meet needs until 1980. Sedimentation and chlorination facilities will be provided for partial treatment of an additional 289 mgd during periods of stormwater runoff. When completed, 40 percent of the combined system flow received at the plant during storms will be given complete treatment and 60 percent will receive partial treatment.

Industrial Wastes

Government is essentially the only "industry" in the Washington Metropolitan Area. Industries that are so essential to the economy of other cities of this size are practically nonexistent. The few significant industries known to discharge directly to streams of the area included those listed in Table 4.

Rock Creek received water softener backwash, boiler blowdown and cooling water from the District of Columbia West Heating Plant, and small quantities of oil from two establishments.

The Anacostia River received cooling water from two electric generating plants and washwater from two sand and gravel plants.

Silt

Erosion occurs throughout the Potomac River Basin (Figure 5 and Table 5), and silt eroded from the farthest point in the watershed ultimately can

Table 3

POTOMAC RIVER

Untreated Sanitary Sewage Overflows to Potomac River

(From separate and combined sewers)

	Sanitary Sewage Overflow Mg/Yr	Percent of Total
A. **Sanitary Sewage Overflows to be Eliminated (1969)** [1]		
Amount included in "1957 Report" data	1,330	25.4
Anacostia Main (incl. Maryland connection)	2,000	38.3
Additional Rock Creek Main Interceptor (RCMI) [2]	1,892	36.3
Total Requiring Elimination	5,222	100.0
B. **Overflows Eliminated by Modified Plan "C" Construction from 1960 to 1966**		
1963 Anacostia Closure	2,000	38.3
1960-1966 Plan "C" Construction [3] (178 closures minus 108 rerouting)	70	1.3
Amount Eliminated, 1966	2,070	39.6
(Amount Remaining to be Eliminated)	(3,152)	(60.4)
C. **Overflow Elimination Expected by 1969**		
Completion of 2-story Sewer	2,000	38.3
Previous 1960-1966 Eliminations	2,070	39.6
Expected Elimination by 1969	4,070	77.9
(Remaining Amount to be Eliminated from 1969-2000)	(1,152)	(22.1)

1. Including flows from Maryland to Anacostia connection and from the 1958-1962 increased flow to the Rock Creek Main Interceptor.
2. The RCMI 108 portion of the 2,000 mgd total was included in the "57 Report" data (2,000-108= 1,892)
3. Total closures effected 178 mgd; but 108 of this from RCMI enters the partially completed 2-story sewer for temporary by-pass downstream (178 - 108 = 70).

Table 4

SOURCES OF INDUSTRIAL WASTE

Potomac, Anacostia and Rock Creek

Location	Industry	Waste Type
Potomac River		
Rock Creek		
	H. & D. Metro Ford Tractor Co.	Tractor cleaning
	D. C. West Heating Plant	Cooling water, boiler & softener blowdown
Anacostia River		
	Mineral Pigments Corp.	Pigments, chrome
	A. H. Smith Sand & Gravel Co.	Sand & gravel wash
	U. S. Naval Ordnance Laboratory	Cooling water
	Wm. H. McCeney Co.	Sand & gravel wash
	Lustine Chevrolet Co.	Engine cleaning
	PEPCO Benning Generating Station	Cooling water
	Potomac Sand & Gravel Co.	Sand & gravel wash
	PEPCO Buzzard Point Generating Station	Cooling water
PEPCO Generating Station		Cooling water
Naval Research Laboratory		Cooling water & radioactive waste

Data Source

Municipal and Industrial Waste Inventory – Potomac River Basin.
Prepared by Chesapeake Field Station – October 1966.

Figure 5

ESTIMATED AVERAGE ANNUAL SEDIMENT YIELDS
AT SELECTED POINTS ON THE POTOMAC RIVER
(Based on U. S. G. S. Estimates)

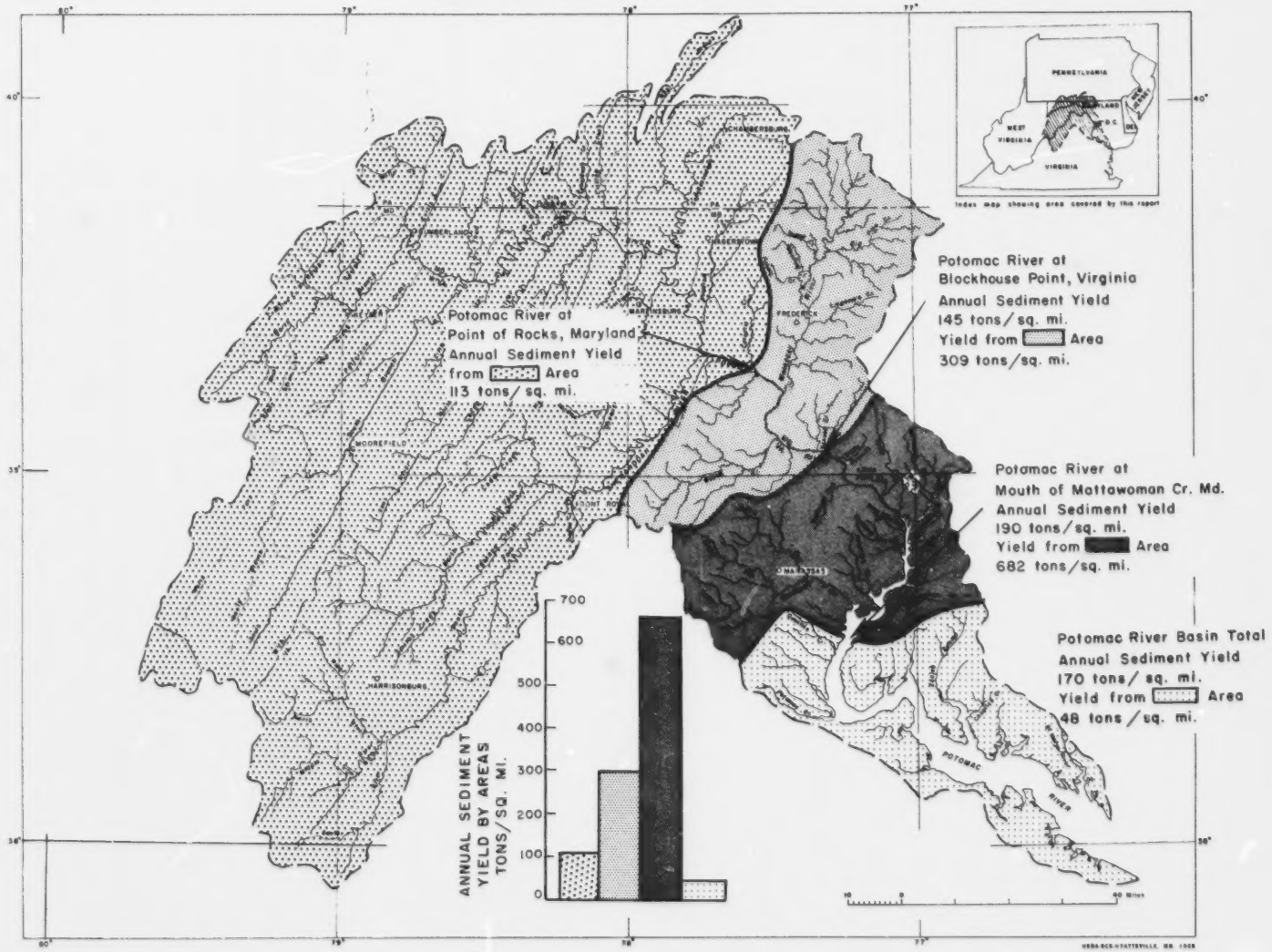


Table 5

Estimated Average Annual Sediment Yields

Location	Area		Yield	Average Yield	
	Sq. Mi.	% of Total	Tons/sq.mi. per Yr.	Tons/Yr.	% of Total
Basin upstream from Point of Rocks, Maryland	9,651	66	113	1,090,000	44
Point of Rocks, Maryland, to Blockhouse Point, Maryland	1,880	13	309	580,000	23
Blockhouse Point, Maryland, to Mattawoman Creek, Maryland. **(Includes area covered by this report)**	1,070	7	682	730,000	29
Mattawoman Creek, Maryland, to mouth at Chesapeake Bay	2,070	14	48	100,000	4
TOTAL	14,670	100.0	170	2,500,000	100

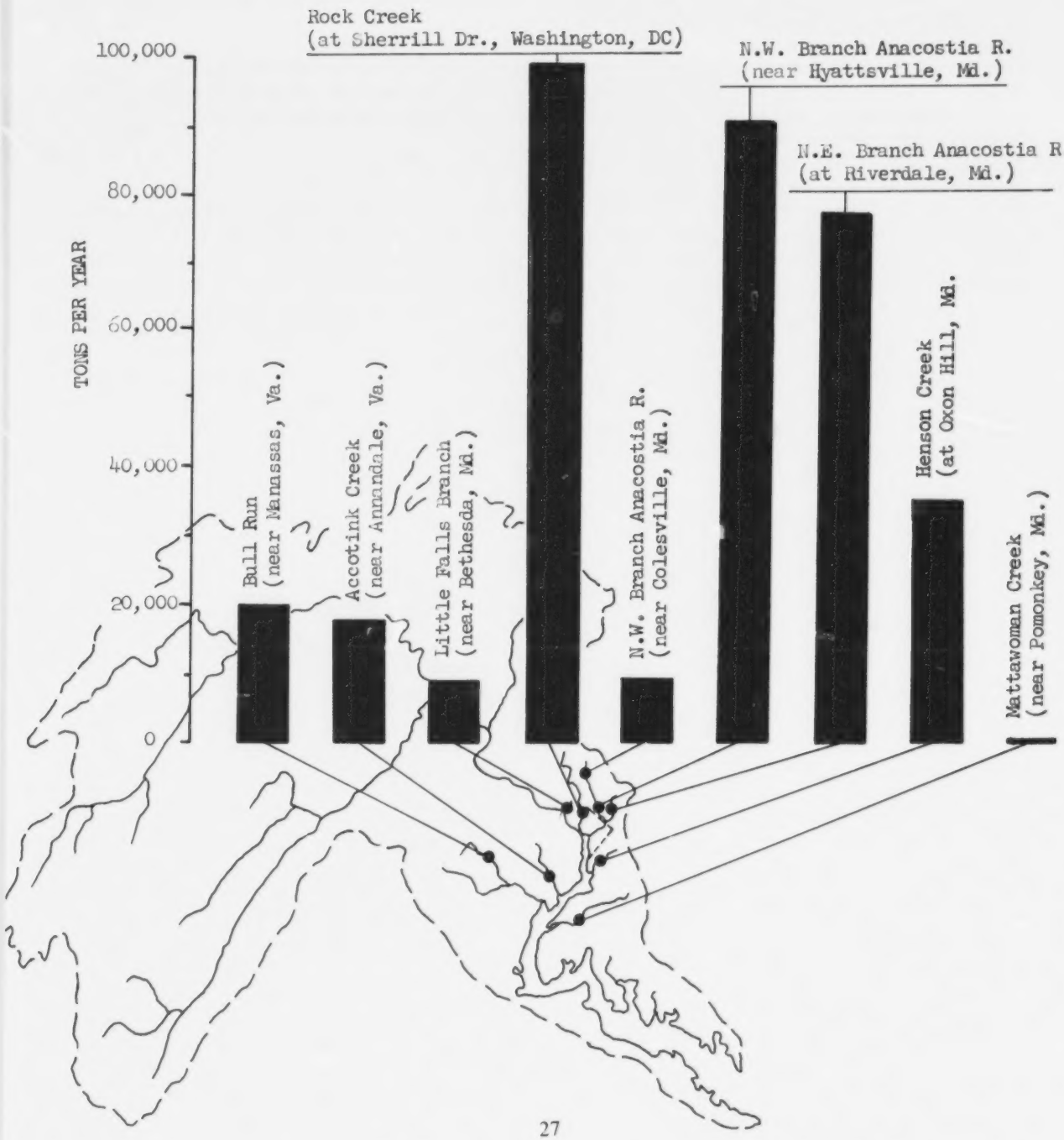
Table 6

Computed Average Annual Discharge of Silt
in Streams in the
POTOMAC RIVER BASIN

STATION	Drainage Area (sq.mi.)	Average Annual Sediment Discharge	
		Tons	Tons per sq. mile
Little Falls Branch (near Bethesda, Md.)	4.1	9,530	2,320
Rock Creek (at Sherrill Drive, Washington, DC)	62.2	99,500	1,600
N.E. Branch Anacostia R. (at Riverdale, Md.)	72.8	77,400	1,060
N.W. Branch Anacostia R. (near Colesville, Md.)	21.3	10,000	470
N.W. Branch Anacostia R. (near Hyattsville, Md.)	47.4	91,300	1,850
Henson Creek (at Oxon Hill, Md.)	16.7	36,000	1,850
Accotink Creek (near Annandale, Va.)	23.6	17,800	690
Bull Run (near Manassas, Va.)	147.0	21,400	146
Mattawoman Creek (near Pomonkey, Md.)	57.7	1,830	32

Figure 6

COMPUTED AVERAGE ANNUAL DISCHARGE OF SILT IN STREAMS
IN THE POTOMAC RIVER WASHINGTON METROPOLITAN AREA



contribute to turbidity of the Potomac River in the metropolitan area, and to deposits on the bottom of the river. The magnitude of the problem of controlling so many sources of silt distributed over such a large area is obvious.

Soil erosion and the quantity of silt that results are greatly influenced by the type of land use. Silt losses vary from as little as 20 tons per square mile per year for forested lands and those with undisturbed vegetative cover to as much as 50,000 tons per square mile per year for construction areas undergoing urban development. It is obvious that erosion is greatest in the most populous areas.

Data on silt contributed to the Potomac from the metropolitan area alone are not available, but 730,000 tons per year were contributed from the area tributary to the river between Blockhouse Point, Virginia, and the mouth of Mattawoman Creek, Maryland. This area comprises only seven percent of the basin's area and includes the metropolitan area. By contrast, the contribution from the 78 percent of the basin above Blockhouse Point was only a little over twice that from the Blockhouse Point-Mouth of Mattawoman Creek area, or 1,670,000 tons per year.

More specific sources of silt, but minor contributors in relation to the total, included strip mines for coal, ceramic clay and glass sands in the upper basin and sand and gravel washing operations in the upper estuary area.

Annual silt loads carried by tributaries of the Potomac River in the general metropolitan area are given in Table 6, and are shown in Figure 6. Two tributaries in the District of Columbia, Rock Creek, with 100,000 tons per year, and the Anacostia River with 169,000 tons per year, contributed nearly 37 percent of the total silt discharge to the Potomac in this area and nearly 11 percent of that in the entire basin. The area drained by the two tributaries represents only about 1.25 percent of the total Potomac Basin.

Stormwater Runoff

Most of the silt reaching the streams is carried there by runoff following rainfall. The runoff, especially from urban areas, contains other constituents that may cause pollution. These include oxygen-demanding organic matter, bacteria, and phosphates among other constituents.

No special studies of the loads of pollutants in surface runoff have been made in the Washington Metropolitan Area.

In spite of the reductions in wastes that have been accomplished since 1957, there has been only minor improvement in the severely polluted condition of the Potomac River.

Data on water quality of the Potomac River have been obtained regularly by personnel of the District of Columbia Water Pollution Control Plant since the plant was placed in operation in 1937. Recent data have been made available for use in this report as they were for the 1957 report.

WATER QUALITY STANDARDS

Under the provisions of Section 10(c)(3) of the Federal Water Pollution Control Act (of 1965), the District of Columbia and the States in the Potomac Watershed, Pennsylvania, Maryland, West Virginia and Virginia, submitted standards for interstate streams to the Secretary of the Interior. Since the State boundary for Virginia follows the near shoreline of the Potomac, Virginia has not set standards for the main stem of the Potomac but has prepared standards for the tributary and estuarine waters in the tidal portions which are within its boundary. The Secretary of the Interior has approved standards for Maryland and, with some exceptions, those of West Virginia, Pennsylvania and the District of Columbia. Standards submitted by Virginia are currently under review.

Water Quality Standards are comprised of criteria to protect specified water uses and plans to attain or maintain these criteria, prevent unwarranted degradation of existing high quality streams, and enhance the quality of degraded streams to allow more beneficial uses. These criteria also provide a basis for evaluating the individual or accumulative effects of various polluting materials.

Each of the standards contain general criteria applicable to all waters and are substantially in accordance with the following:

The water shall not contain substances attributable to municipal, industrial, or other waste discharges in concentrations or amounts sufficient to be inimical or harmful for water uses or to human animal, plant or aquatic life Specific substances to be controlled include, but are not limited to, debris, oil, scum, and other floating materials; toxic substances; substances that produce color, tastes, odors, or settle to form sludge deposits.

In addition to the General Criteria, specific criteria to protect water have been adopted for designated zones of the interstate coastal waters. The water quality standards in table form for the interstate waters of the Potomac River are presented in Table I of the Appendix. The code used in Table I to identify the criteria adopted for a specific zone is explained in Table II.

The Secretary of the Interior has stated that a basic policy of the Act is to protect and enhance the quality of the Nation's waters and has concluded that implementation of this policy requires substantially the following:

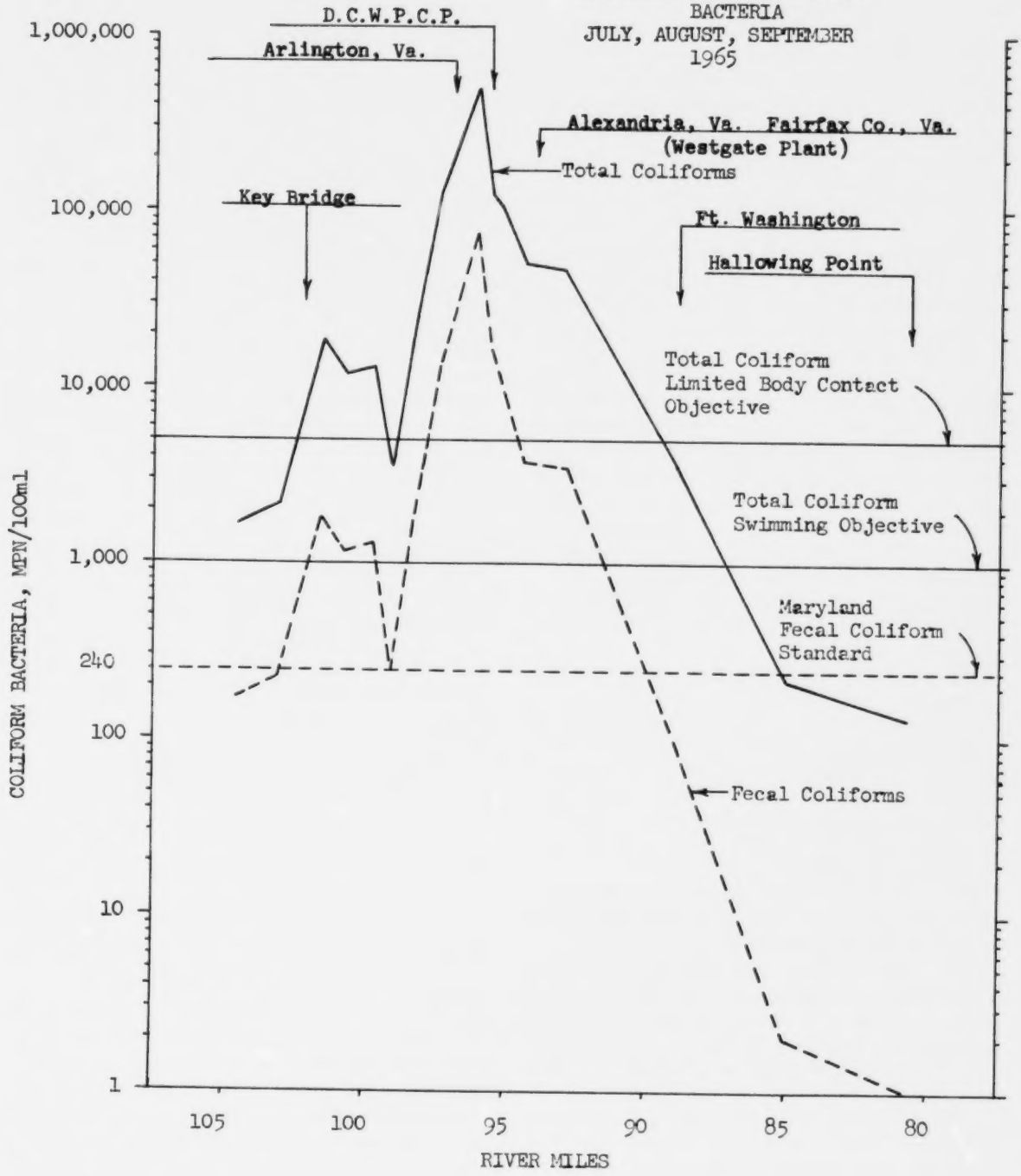
"Waters whose existing quality is better than the established standards as of the date on which such standards become effective will be maintained at their existing high quality. These and other waters of the District will not be lowered in quality unless and until it has been affirmatively demonstrated to the District of Columbia water pollution control agency and the Department of the Interior that such change is justifiable as a result of necessary economic or social development and will not interfere with or become injurious to any assigned uses made of, or presently possible in, such waters. This will require that any industrial, public or private project or development which would constitute a new source of pollution or an increased source of pollution to high quality waters will be required, as part of the initial project design, to provide the highest and best degree of waste treatment available under existing technology, and, since these are also Federal standards, these waste treatment requirements will be developed cooperatively."

BACTERIAL POLLUTION

The 1957 report presented bacteriological data that were cited as being ". . .a picture of extreme bacterial contamination which renders the river hazardous to the health of those who use it for any type of recreation that involves contact with the water." It was stated also that "At no point can it be considered safe for swimming." There has been only moderate improvement in bacterial control through sewage treatment since then, and the conclusions of that and of earlier reports regarding the grave hazards to health of using the

Figure 7

POTOMAC RIVER ESTUARY
OBSERVED TOTAL COLIFORM
BACTERIA
AND
CALCULATED FECAL COLIFORM
BACTERIA
JULY, AUGUST, SEPTEMBER
1965



river for recreation still apply. Data on coliform bacteria provided by the staff of the District of Columbia Water Pollution Control Plant serve as the basis for this conclusion.

Figure 7 and Table III-Appendix show the average most probable numbers (MPN) of coliform bacteria for the Potomac River for the months of July, August and September, 1965, which was a low stream flow period (846 cfs). Limits of coliform bacteria commonly used are 1,000 per 100 ml (a little less than one-half cup of water) for swimming and other whole-body contact sports and 5,000 per 100 ml for limited-body contact sports, such as boating and fishing. On this basis, the river was unsuitable for any type of recreation from Key Bridge downstream almost to Fort Washington, a distance of about 13 miles. It would be unsuitable for swimming from Fletchers Boat House, above Three Sisters Island, to one mile below Fort Washington, a distance of more than 16 miles.

The maximum three-month average coliform density observed in 1965 was 521,000 per 100 ml just above the District of Columbia sewage plant. This was more than 100 times the partial-body contact limit and over 500 times the body contact limit. It was equal to more than 300 coliform bacteria per drop of water.

The bacterial standard for the Maryland portion of the Potomac River is not based on total coliform, but on the more recently developed method for fecal coliform bacteria. These bacteria are essentially all of fecal origin and therefore are much more specific for fecal pollution than are total coliforms.

No fecal coliform data were available for the reach of the Potomac River under consideration. However, it is possible to estimate the probable fecal coliform densities within reasonable limits on the basis of fecal coliform data obtained on other streams.

Calculated fecal coliform densities are incorporated in Figure 7 with the observed total coliform data discussed above. The calculated peak value of 78,000 fecal coliforms per 100 ml just above the District's plant outfall is more than 300 times the Maryland limit of 240 per 100 ml for recreation The estimated densities exceed this limit from about Key Bridge to Fort Washington, a distance of a little more than 13 miles.

Data obtained by the total coliform method show that sewage discharged in the Washington Metropolitan Area causes a serious hazard to health of all who use the Potomac for any type of recreation. This conclusion is strongly supported by estimated densities of fecal coliform bacteria, which are the basis for the approved Maryland water quality standards.

A limited quantity of fecal coliform data is available on Rock Creek in Maryland (Table 7). Seven of 10 sampling stations yielded fecal coliform densities in excess of the Maryland standard of 240 per 100 ml. The greatest average density of 2,570, or about 10 times the standard, occurred at the station nearest the District of Columbia line. No fecal coliform data were available on Rock Creek in the District, but data on total coliforms at five stations have been accumulated over a period of years (Table 8). Since 1963 the monthly average total coliform density has exceeded 5,000 per 100 ml at all stations every month of the warm weather period, July through September. More than half the monthly averages exceeded 25,000 per 100 ml, and several exceeded 100,000 per 100 ml.

In both Maryland and the District of Columbia, water-contact uses of Rock Creek involved a distinct hazard to health.

Bacterial data on the Anacostia River were available for only the District of Columbia reach of the river (Table 9). Averages for July through September have been quite erratic at the seven sampling stations within the District. In 1963 average total coliforms at five of the seven stations approached or exceeded one-half million per 100 ml, indicating the probable discharge of raw sewage to the river. In 1964 and 1965 densities were much lower, with no monthly average exceeding 100,000 per 100 ml, though densities generally were greater than 5,000 per 100 ml. In 1966 densities increased, with averages at three of the seven stations exceeding one-half million The lowest density always had occurred at the station nearest the mouth of the river, indicating that the bacterial pollution came from upstream rather than from the Potomac River through tidal action.

Contact with the water of the Anacostia River within the District of Columbia was hazardous to health.

OXYGEN DEMAND

Sewage and many industrial wastes contain organic matter that decomposes in water and in so doing exerts a demand on the dissolved oxygen of the receiving stream. If the oxygen demand is great enough and the ability of the stream to

Table 7

Bacteriological Analyses of Rock Creek Grab Samples – June and August 1966

Miles from Potomac River Confluence	Sample Location	Number of Samples	Coliforms (MPN/100ml)	Fecal Coliforms (MPN/100ml)	Fecal Streptococci (MPN/100ml)
> 23.8	Needwood Road	1	1,300	330	93
> 23.8	Muncaster Road	2	3,350	1,850	1,140
23.8	Avery Road	2	1,100	110	250
23.1	Norbeck Road	1	460	210	130
21.2	Viers Mill Road	2	1,020	315	150
17.3	Knowles Avenue	1	2,400	1,300	330
14.8	Cedar Lane	7	26,500(a)	1,740	1,980
14.6	NNMC – Bethesda	1	2,400	61	20
13.5	Kensington Avenue	1	9,200	260	110
11.3	Coquelin Run				
11.1	East-West Highway	5	58,400(a)	2,570	8,190

(a) One result reported as > 160,900. For arithmetic average, the density was taken as 160,900.

Table 8

Summary of Average Monthly Coliform Densities for the D.C. Reach of Rock Creek

Year	Coliform Density (MPN/100 ml)				
	Pennsylvania Avenue (0.6)	Park Road (3.9)	Military Road (7.6)	Sherrill Drive (8.6)	D.C. Line (9.1)
1962					
July	-	-	-	-	-
August	-	-	-	-	-
September	-	-	-	-	-
1963					
July	105,000	32,000	30,400	71,000	8,350
August	107,000	40,000	15,500	47,000	100,000
September	33,200	32,000	20,600	51,500	4,640
1964					
July	55,000	38,000	35,000	13,000	36,000
August	23,000	14,500	12,000	25,000	10,600
September	18,000	20,000	7,800	13,000	33,000
1965					
July	94,000	25,000	37,000	48,000	24,000
August	121,000	92,000	76,000	100,500	60,000
September	41,600	37,000	39,000	40,000	40,000
1966					
July	594,000	12,650	27,200	45,577	45,580
August	39,320	17,780	9,505	16,380	24,220
September	31,170	15,170	35,530	161,770	9,600

NOTE: With the exception of 1963, the coliform densities are arithmetic averages. The 1963 densities are geometric mean values.

The number in parentheses under each sampling station is the miles from the confluence with the Potomac River.

Table 9

Summary of Average Coliform Densities for the Anacostia River

Year[a]	Total Coliforms (MPN/100 ml)						
	Washington Channel (1.1)	South Capitol Street (2.0)	11th Street Bridge (2.8)	Pennsylvania Avenue (3.6)	East Capitol Street (4.8)	Benning Street (5.3)	D.C. Line (7.2)
1962	6,050	51,300	82,500	122,000	943,000	124,000	121,000
1963	24,200	477,000	430,000	948,000	3,510,000	458,000	27,700
1964	3,760	9,180	17,900	21,800	6,060	37,200	41,400
1965	2,580	4,680	94,600	30,100	34,800	27,400	21,400
1966	9,030	111,000	578,000	163,000	42,900	555,000	608,000

(a) Arithmetic average for samples collected during July, August, and September.

NOTE: For each sampling station, the number in parentheses refers to the miles from the confluence with the Potomac River.

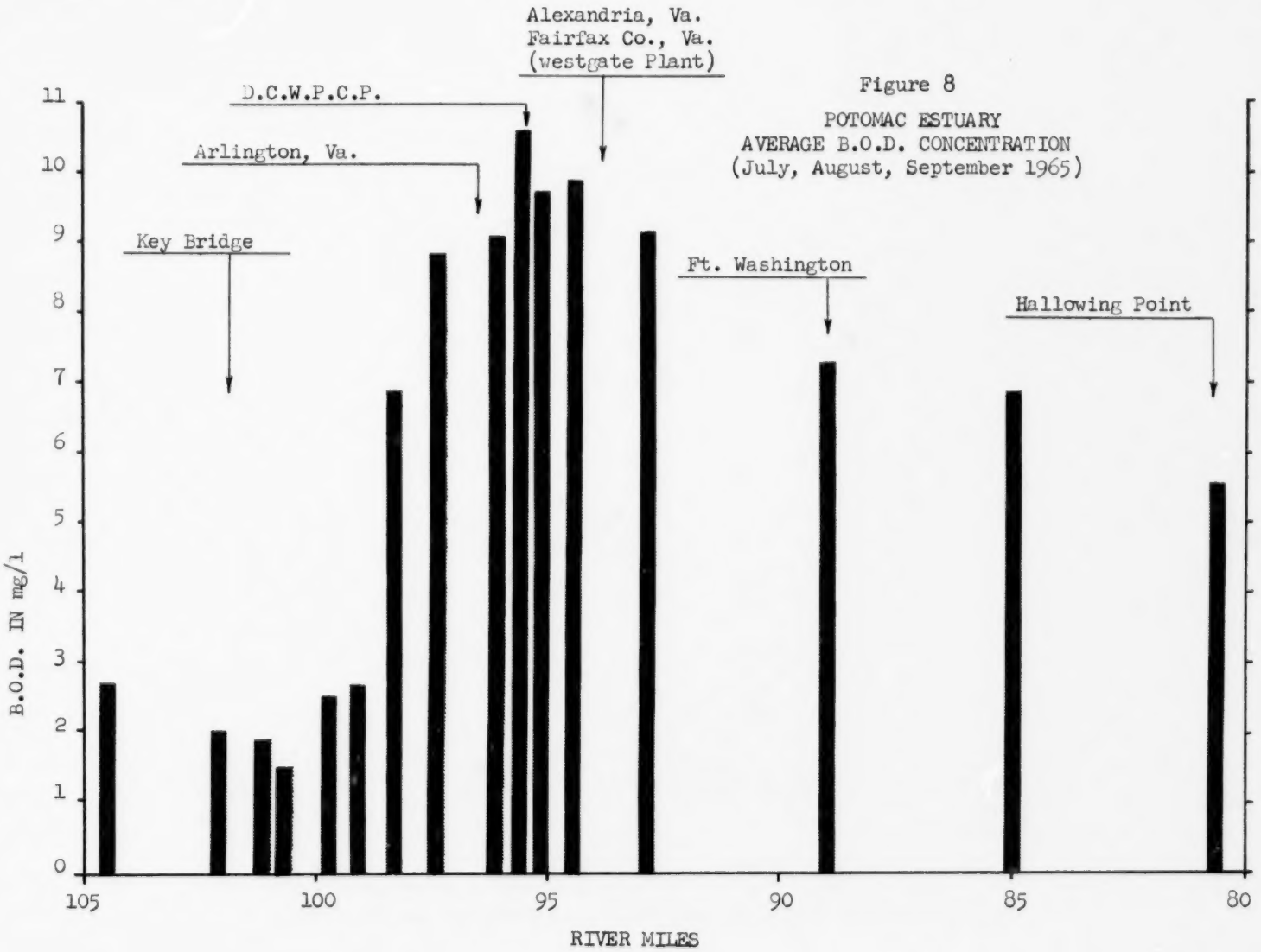


Figure 8

POTOMAC ESTUARY
AVERAGE B.O.D. CONCENTRATION
(July, August, September 1965)

Table 10

Summary of Average Monthly 5-day BOD's for the D.C. Reach of Rock Creek

5-day BOD ($20^{o}C$) – (mg/1)

Year	Pennsylvania Avenue	Park Road	Military Road	Sherrill Drive	D.C. Line
1962					
July	2.6	0.7	2.4	2.9	3.1
August	1.7	2.0	1.7	1.8	2.2
September	-	-	-	-	-
1963					
July	3.3	3.2	3.7	3.3	1.2
August	1.8	3.1	2.4	2.4	2.1
September	0.9	2.1	1.3	2.6	1.4
1964					
July	2.7	3.5	3.2	4.3	3.7
August	2.0	1.8	1.7	1.9	2.3
September	2.3	2.4	1.4	1.8	2.0
1965					
July	3.7	2.1	2.5	2.9	3.4
August	9.2	7.2	10.3	8.7	6.2
September	4.7	3.9	3.9	4.7	3.6
1966					
July	5.7	1.6	1.1	1.3	1.0
August	6.0	3.1	2.6	3.5	5.6
September	2.3	3.5	1.6	2.0	2.0

recover oxygen from the atmosphere is limited, the essential dissolved oxygen may be reduced to levels that will not support fish and other aquatic life. In extreme cases, if the dissolved oxygen is totally exhausted, the stream gives off the offensive odors of decomposition

Some, or all, of the organic matter that causes oxygen demand may be carried in the water, but some of the insoluble material may settle to the bottom of the stream, where it forms sludge deposits and continues to exert an oxygen demand.

The oxygen demand of organic matter is exerted over a period of many days, and in the Potomac River estuary where tidal action retains the wastes for a long time, it is necessary to consider the ultimate oxygen demand including that caused by nitrogen compounds. Although measurement of the demand in the laboratory is usually limited to 5 days, it is possible by use of appropriate factors to determine the ultimate demand. The standard 5-day value is known as the 5 day biochemical oxygen demand, or BOD_5.

Biochemical Oxygen Demand

Average BOD_5 values of the water of the Potomac River for the low stream flow months of July through September, 1965 are shown in Figure 8 and Table III-Appendix. The 2.7 mg/1 of BOD_5 at the farthest upstream sampling point, Fletchers Boat House, was higher than is usual for an unpolluted stream and probably reflected residual organic pollution from upstream wastes.

The BOD_5 dropped to 1.5 mg/1 at Arlington Memorial Bridge, and then started to climb as the tidal action of the Potomac carried sewage upstream from the point of discharge of the District of Columbia Water Pollution Control Plant effluent. The BOD_5 reached 10.6 mg/1 opposite the D.C. plant and then dropped to 5.6 mg/1 at Hallowing Point, the farthest downstream sampling station. This value was relatively high for an estuary.

Average monthly BOD_5 values for Rock Creek within the District of Columbia for the months of July through September, 1962 through 1966, are shown in Table 10. The monthly values were variable and did not exhibit any consistent pattern. A few values were relatively high (10.6 mg/1 maximum) probably reflecting the effects of intermittent storm water runoff or overflow from a sewer. In general, the monthly averages were not excessive for a shallow, swift stream of this type

The BOD_5 data for Anacostia River within the District in Table 11 are similar to those for Rock Creek. They exhibited no definite pattern and although the single maximum BOD_5 (7.8 mg/1) was not so high as the maximum for Rock Creek, on the whole the values for the Anacostia tended to be higher than those for Rock Creek

The Anacostia River within the District is much deeper and slower than Rock Creek, and therefore has a much lower reaeration capacity. The BOD_5 values for the Anacostia could seriously deplete the DO of this stream.

Bottom Oxygen Demand

In addition to the BOD_5 of the river water, independent measurements were made of oxygen demand of sludge deposits. The results are shown in Figure 9. About 1 gram of oxygen demand per square meter per day is normal for an unpolluted estuary. The maximum measured values were nearly three times this in the vicinity of and below the D.C. Water Pollution Control Plant. The sludge oxygen demand was 2 grams per square meter per day or greater, indicative of gross pollution for a distance of 10 miles, from East Potomac Park to 0.5 mile above Riverview, Maryland. The effluent from four major sewage treatment plants of the metropolitan area discharges in this reach, and suspended solids from these plants contributed to the sludge deposits that caused the high oxygen demand.

DISSOLVED OXYGEN

Average and minimum dissolved oxygen (DO) values for July through September 1965 are shown in Figure 10 and are tabulated in Table III-Appendix. The river entered the estuary with an average DO of 7.4 mg/1. The average DO dropped below 5 mg/1 about three miles above the D.C. plant and fell as low as 2.8 mg/1 opposite the plant. It remained below 5 mg/1 to Fort Washington for a total distance of about eleven miles.

The minimum DO for the same period was 6.0 mg/1 at Fletchers Boat House, dropped below 4 mg/1 about 6 miles above the D.C. plant and continued down to a very low 0.4 mg/1 opposite the plant. The minimum at the D.C. - Maryland line was about 1.1 mg/1, and did not rise above 4.0 mg/1 until about three miles upstream from Hallowing Point. Only coarse and pollution

Table 11

Summary of Average 5-day BOD Concentrations for the Anacostia River

Year[a]	5-day BOD ($20^{o}C$) – (mg/1)						
	Washington Channel	South Capitol Street	11th Street Bridge	Pennsylvania Avenue	East Capitol Street	Benning Street	D.C. Line
1962	3.0	3.8	4.0	4.0	5.5	5.2	5.7
1963	5.3	6.6	5.3	6.2	7.8	6.7	5.0
1964	3.4	4.8	3.9	3.9	2.4	2 9	4.4
1965	6.6	5.3	6.2	5.5	4.7	4.4	3.5
1966	5.5	6.1	4.7	4.1	6.4	5.2	5.2

(a) Arithmetic average for samples collected during July, August, and September.

Figure 9
POTOMAC RIVER ESTUARY
BENTHAL UPTAKE vs. RIVER MILES
BENTHAL LOAD AT 25°C.
TEMP. CORRECTION - 6%/°C.
(Measured by Chesapeake Field Station)

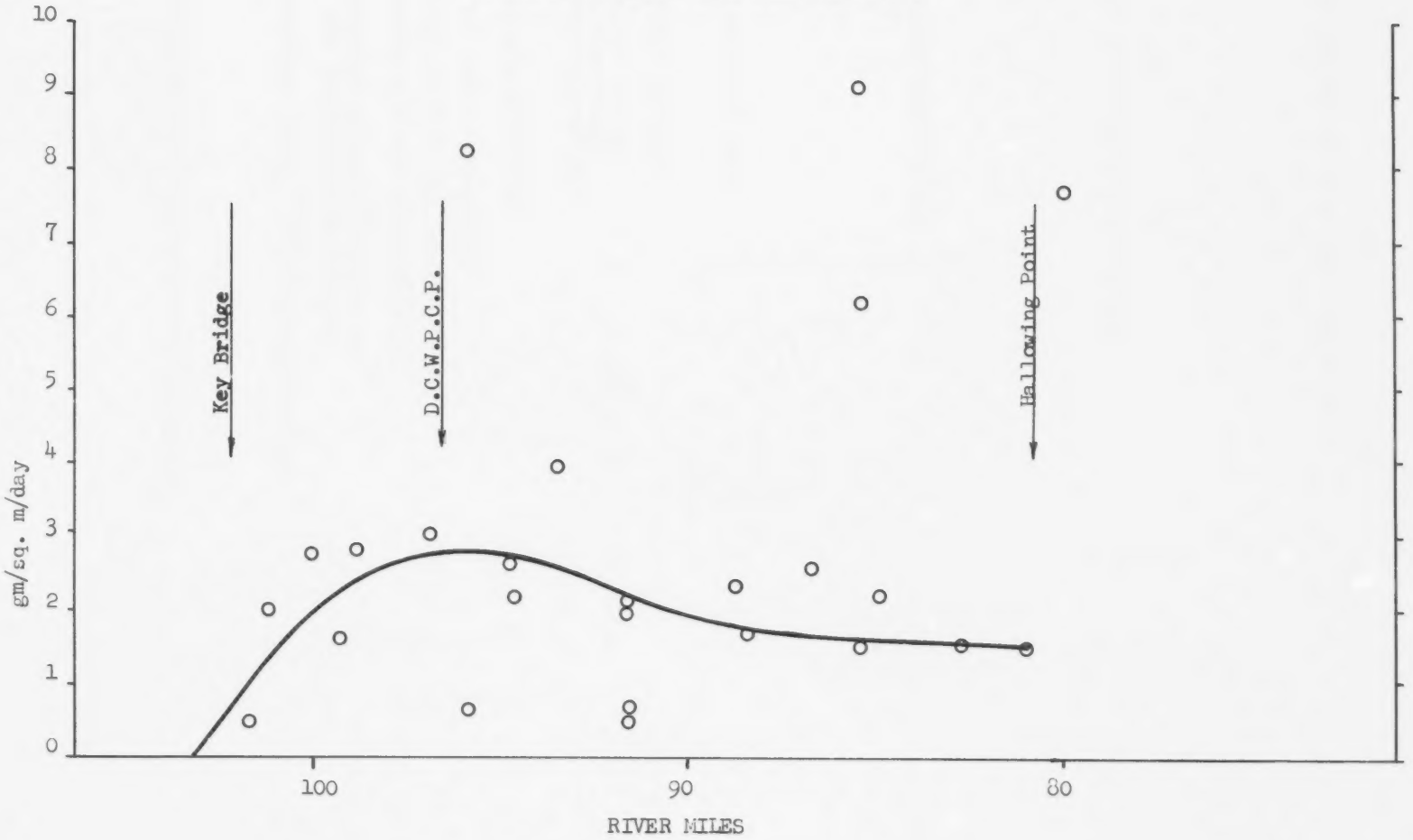


Figure 10

POTOMAC ESTUARY
AVERAGE DISSOLVED OXYGEN CONCENTRATION
(July, August, September 1965)

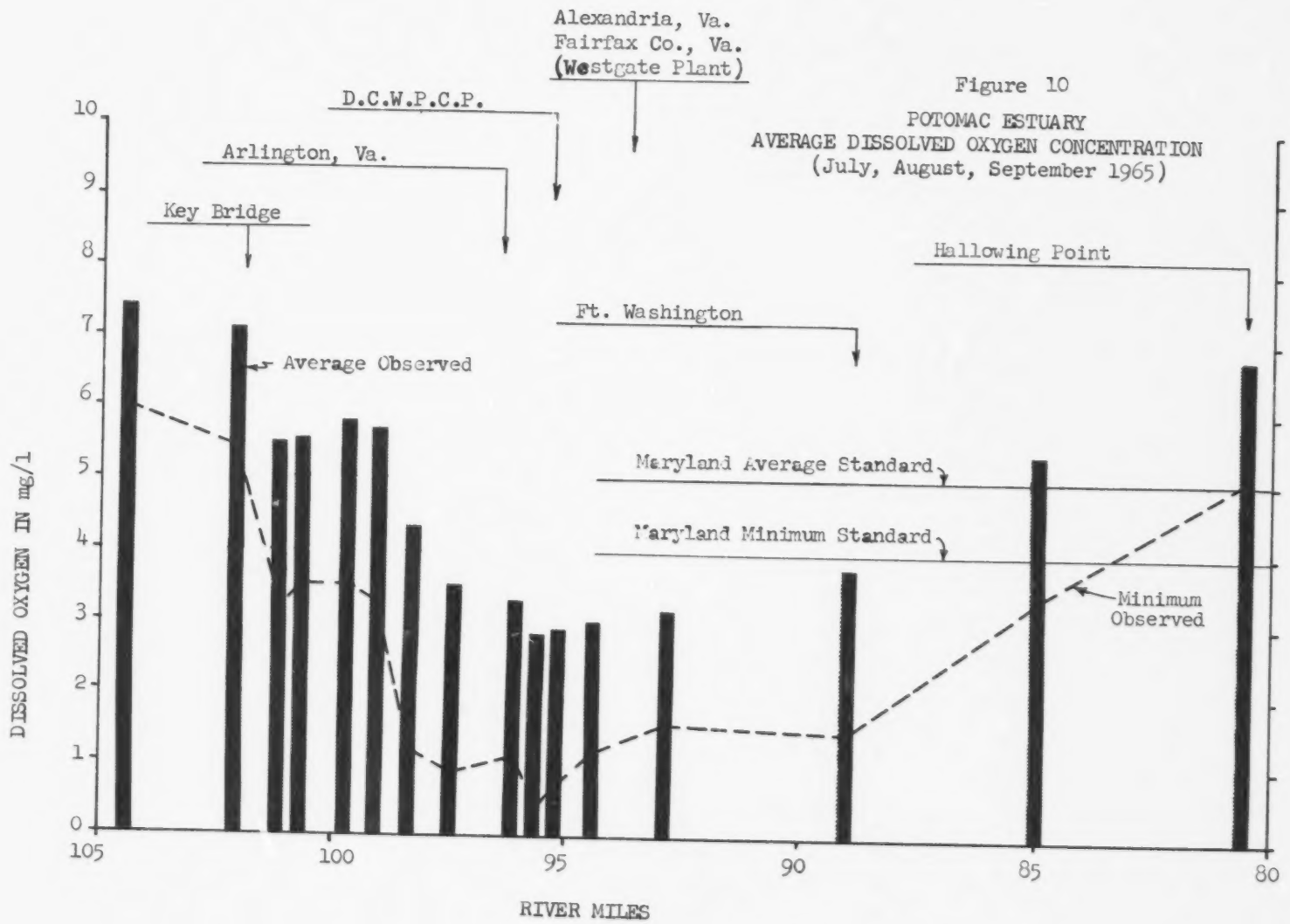


Table 12

Summary of Average Monthly Dissolved Oxygen Concentrations for the D.C. Reach of Rock Creek

Year	Dissolved Oxygen (mg/1)				
	Pennsylvania Avenue	Park Road	Military Road	Sherrill Drive	D.C. Line
1962					
July	7.6	8.4	7.5	8.2	7.6
August	8.4	8.8	9.0	7.8	6.8
September	8.0	8.8	7.9	8.7	7.6
1963					
July	8.5	8.8	9.4	7.9	9.2
August	7.3	9.1	8.3	7.8	7.8
September	8.5	9.1	8.8	7.9	8.3
1964					
July	7.5	8.6	8.1	7.7	7.5
August	8.4	9.4	9.1	8.3	8.2
September	7.6	9.4	9.0	7.8	7.9
1965					
July	7.8	7.8	8.6	8.8	7.8
August	6.9	7.9	6.3	5.9	5.5
September	8.3	9.4	8.6	8.1	7.4
1966					
July	6.5	8.9	8.7	7.9	7.3
August	7.6	9.6	8.7	7.9	7.6
September	8.2	9.3	8.1	7.7	8.1

Table 13

Summary of Average Dissolved Oxygen Concentrations for the Anacostia River

Dissolved Oxygen (mg/l)

Year[a]	Washington Channel	South Capitol Street	11th Street Bridge	Pennsylvania Avenue	East Capitol Street	Benning Street	D.C. Line
1962							
Minimum	2.1	1.2	1.4	1.3	1.1	1.1	1.5
Average	5.0	3.0	2.9	2.9	3.1	3.8	4.3
1963							
Minimum	3.6	0.9	0.9	0.5	1.8	0.6	1.7
Average	5.6	3.6	2.7	2.9	3.1	3.4	4.0
1964							
Minimum	5.2	3.7	3.2	2.7	2.4	2.3	2.9
Average	5.9	4.3	4.6	3.3	7.4	3.3	4.2
1965							
Minimum	2.9	2.7	1.4	1.4	2.5	3.0	2.6
Average	6.5	4.4	3.1	3.0	3.2	3.9	3.5
1966							
Minimum	2.8	1.4	2.4	2.3	3.7	3.3	2.0
Average	5.5	3.1	4.4	4.1	5.5	5.6	4.6

(a) The minimum concentration refers to one specific sample. The arithmetic average refers to all the samples collected during July, August, and September.

resistant fish, such as carp and catfish, can be expected in waters with DO as low as this, and even they would not survive in the vicinity of the D.C. plant effluent where DO approached zero.

The average DO levels in Rock Creek for July through September 1962 through 1966 are presented in Table 12. They indicate no excessive oxygen depletion with only two values below 6.0 mg/l and with a minimum of 5.5 mg/l.

Both average and minimum DO levels of the Anacostia River (Table 13) have been low over the years, with minimum values below 1 mg/l at several stations in 1963. There was a trend toward improvement through 1966, but even in that year DO depletion still was excessive, with averages below 5 mg/l and minimum values below 4.0 mg/l at all stations, in the vicinity of 2.0 mg/l at several, and as low as 1.4 mg/l at one.

This reach of the Anacostia River would not support a desirable fish population.

ALGAE

Algae are aquatic plants that range from simple microscopic forms to masses of green and blue-green filaments that may become so abundant that they constitute a nuisance. The microscopic forms can color the water green and may form obnoxious floating scums. They may cause tastes and odors in water supplies and problems of operation in water treatment plants. Changes in water characteristics may cause great numbers of algae to die. They decompose; this decomposition imposes a demand on the DO in the stream which, in addition to the DO used by decomposing man-associated organic pollution may cause serious oxygen depletion, fish deaths and offensive odors. Filamentous algae may line the shore of beaches with slimy masses that make bathing unpleasant or even disagreeable. They can interfere with fishing by collecting in masses on fish hooks, bait and lines. They may wash up on the shore and die to decompose and produce offensive odors.

In waters remote from human influence, phosphorus exists in very low concentrations, principally as a result of solution from the soil. Seasonal changes in aquatic plant and animal production result in cyclic utilization and release of phosphorus to the water. Land runoff carries phosphates from the soil. The discharge of domestic sewage increases the concentration of phosphorus. Phosphorus in the sewage including phosphates from synthetic detergents are the principal contributions. The additional phosphorus may result in concentrations in the receiving water that are above the minimum requirements for nuisance plant growths.

As nutrient concentrations increase, the numbers of algal cells usually increase. Although some phosphorus is essential to support aquatic life, an upper limit of 0.1 mg/l of total phosphorus (as P) appears to limit algal growths in the Potomac estuary. Concentrations exceeding this level have resulted in nuisance algal blooms.

Another essential nutrient is nitrogen. Nitrogen comes into solution in water as the result of nitrogen fixation by bacteria and blue-green algae from the air, ammonia from rain-out, organic nitrogen from decomposing plants and animals, and from land drainage. The discharge of human wastes results in additional nitrogen. Because of the availability of nitrogen from the atmosphere, it is less amenable to control than phosphorus. More than a total of 0.3 mg/l (as N) of ammonia, nitrate and nitrite nitrogen along with adequate phosphorus will support an abundance of algal growths.

One of the products of algal growth is chlorophyll, the compound that causes the green color of algae and is essential in the photosynthetic reaction that results in the liberation of oxygen from the carbon dioxide used by plants in their growth. Measurement of chlorophyll in water provides one index of the abundance of algae in a stream. When algae are excessive, chlorophyll has been found generally to exceed 50 micrograms per liter (µg/l).

Determinations of phosphorus, nitrogen and chlorophyll were made in the Potomac River estuary during 1965 and 1966.

Phosphorus

Average annual total phosphorus concentration in the Potomac at Great Falls during 1966 was 0.109 mg/l.

In January through June 1966 total phosphorus (P) in the Potomac near Woodrow Wilson Bridge, downstream from the D.C. Water Pollution Control Plant averaged 0.522 mg/l, and during an unusually low flow period (300 cfs) in early September the phosphorus ranged from 1.18 to 1.99 mg/l.

Phosphorus was measured at approximately monthly intervals in the vicinity of Fort Washington (mile 88) from March 1965 through April 1966 (Table 14 and Figure 11). Total

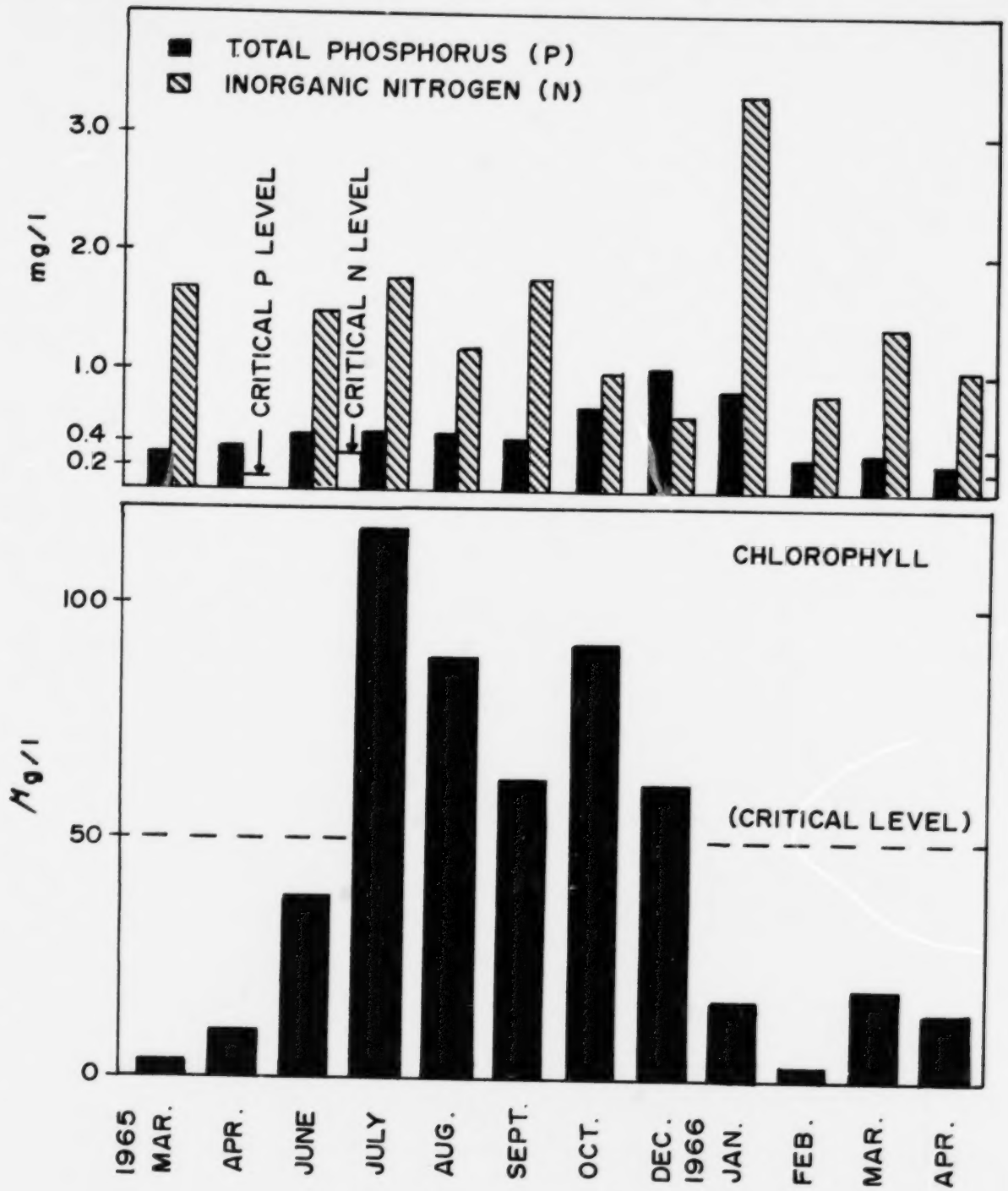
Table 14

Potomac River Nutrient and Chlorophyll Data, Mile 88*

Date	Chlorophyll µg/l	Total Phosphorus P mg/l	Inorganic Phosphorus P mg/l	Inorganic Nitrogen N mg/l
March 23-25	2.6	.252	.180	1.742
April 27-28	9.9	.270	.217	
June 2-3	35.5	.428	.410	1.514
July 7-8	115.0	.490	.388	1.823
Aug. 9-11	87.5	.475	.375	1.237
Sept. 14-15	62.5	.444	.388	1.889
Oct. 19-20	91.0	.744	.264	1.069
Dec. 1-2	61.0	1.178	.822	.637
Jan. 19-20	15.4	.868		3.357
Feb. 23-24	3.8	.341	.226	.835
March 23-24	17.0	.369	.223	1.677
April 25-28	14.0	.248	.136	1.124
Avg.		.509	.330	1.878

* Data from Nutrient Cruises conducted during 1965-1966 by the Chesapeake Bay Institute, the Johns Hopkins University.

FIGURE 11 POTOMAC RIVER NUTRIENTS AND CHLOROPHYLL MILE 88



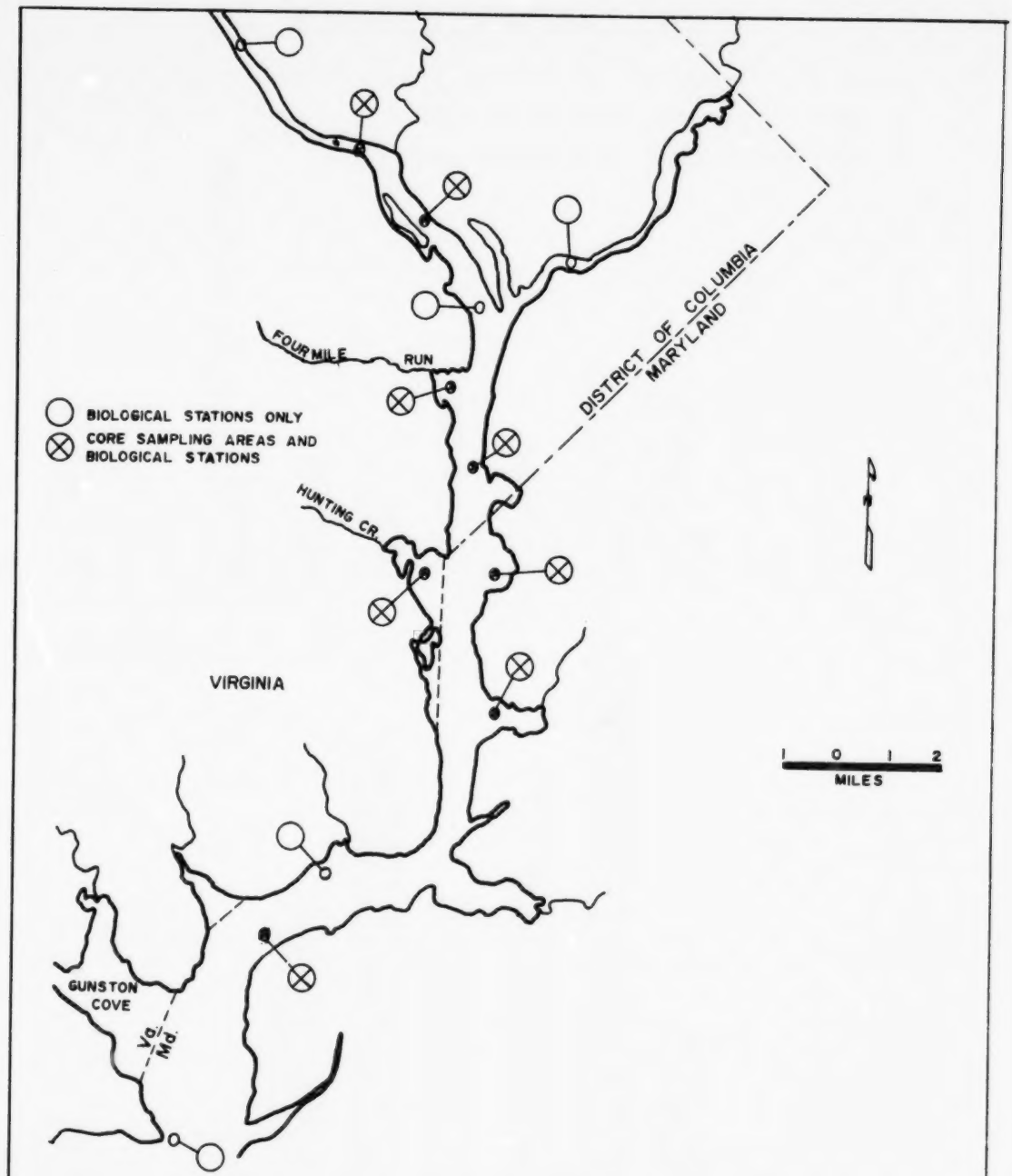


FIGURE 12 POTOMAC RIVER DRAINAGE AND BIOLOGICAL SAMPLING STATIONS

phosphorus concentrations exceeded 0.25 mg/l on all occasions, and rose as high as 1.18 in December 1965.

Nitrogen

Nitrogen determinations were made in parallel with those for phosphorus (Table 14 and Figure 11). At Great Falls, Maryland, the inorganic nitrogen (N) during 1966 was 1.05 mg/l. It was never less than 0.64 mg/l at mile 88 at the time of any sample collection. The maximum value reported was 3.36 mg/l in January 1966, near Fort Washington (mile 88).

Nitrogen was more than sufficient to support abundant growths of algae.

Chlorophyll

Chlorophyll in the vicinity of Fort Washington (Table 14 and Figure 11) exceeded 50 µg/l from July through December 1965, reaching a high of 115.0 µg/l in July, thus indicating severe algal blooms.

BOTTOM CONDITIONS

Samples for bottom dwelling organisms and river bed materials were collected during February 1967. Stations at which samples were taken are shown in Figure 12.

Bottom Organisms

Bottom dwelling organisms are classified in three broad categories with respect to their reaction to pollution. These are: clean-water or pollution sensitive organisms that are intolerant of pollution; intermediate organisms that are tolerant of moderate pollution; and pollution-tolerant organisms. A clean stream usually supports several kinds of clean water forms, moderate numbers of intermediate forms and very few pollution-tolerant forms. Mild pollution results in loss of a few pollution-sensitive forms and a slight increase in intermediate forms. More severe pollution may eliminate all clean water forms, markedly increase intermediate forms and increase pollution-tolerant organisms. Gross pollution that is not toxic is marked by a lack of clean-water forms, a paucity of intermediate forms and a predominance of pollution-tolerant forms.

In the Potomac River from Little Falls through Little Falls Rapids (Table 15 and Figure 13), only 3 kinds of clean-water bottom animals occurred along with a few pollution-tolerant organisms. Total organism population was a sparse 40 per square foot of rocky bottom.

At Key Bridge (mile 102.5E) there were 409 organisms per square foot, most of which were pollution-tolerant sludgeworms and bloodworms. No clean water forms occurred.

Immediately downstream from the D.C. plant (mile 95.6E), there were about 600 pollution-tolerant sludgeworms per square foot, and no clean water organisms.

About 2 miles downstream from the D.C. plant there were a limited number of intermediate forms but sludgeworms and bloodworms were found in populations of 640 and 1120 per square foot.

Moderate improvement in water quality occurred downstream as shown by the reduction in sludgeworms to less than 200 per square foot in the next eight miles of river.

At Marshall Hall and Hallowing Point bottom organisms were not a reliable indicator of pollution because of the intrusion of salt water into this reach. Both fresh and brackish water organisms occurred here.

The effects of pollution on water quality and clean-water bottom organisms, that serve as food for sport fishes, was reflected in a reduction in the fishing in this reach of the Potomac estuary. The U.S. Fish and Wildlife's Bureau of Sport Fisheries and Wildlife has estimated that pollution has caused an annual loss of 333,480 fishing man-days in the reach from Great Falls downstream to Occoquan Bay (about five miles downstream from Hallowing Point). This represents 21 percent of the total sustained fishing opportunity available in this area.

The lack of suitable bottom organisms is attributed to wastes from the District of Columbia, but bottom organisms were adversely affected also at the mouth of Hunting Creek, which receives treated sewage from Alexandria, Virginia, and in the bay at the mouth of Fourmile Run which receives treated sewage from Arlington, Virginia. Only pollution tolerant organisms were found in both locations.

The results of biological surveys on Rock Creek in August 1966 and February 1967 are presented in Table 16 and Figure 14.

In the upper reaches of Rock Creek upstream from Rockville, Maryland, there were 15 different kinds of bottom organisms, totaling nearly 100 per square foot, most of which were clean-water forms. The quality of the water decreased as it approached the District line, where 12 kinds of bottom organisms numbering 40 per square foot

Table 15

Summary of the Number of Bottom Animals Per Square Foot, Potomac River
Washington, D. C. and Maryland
1965-1967

Station (River Mile)	106.2W*	102.5E	100.7E	98.6-1.3C	96.7W	95.6E	94.0W	94.0E	91.5E	86.5E	85.0E	80.7W
POLLUTION-SENSITIVE ORGANISMS												
Stoneflies												
Taeniopteryx	5	–	–	–	–	–	–	–	–	–	–	–
Caddisflies												
Hydropsyche	2	–	–	–	–	–	–	–	–	–	–	–
Cheumatopsyche	2	–	–	–	–	–	–	–	–	–	–	–
INTERMEDIATE ORGANISMS												
Freshwater Shrimp												
Gammaridae	3	–	–	–	–	–	–	–	–	–	–	–
Clams												
Musculium	–	–	–	–	–	–	–	4	4	–	–	–
Pisidium	–	–	–	–	–	–	–	4	–	–	–	–
Uniomerus	–	–	–	–	–	–	–	–	4	–	–	–
Freshwater Snails												
Gastropoda	Q	Q	–	–	–	–	–	–	–	–	–	–
Roundworms												
Nematodes	2	–	–	–	–	–	–	–	–	–	–	–
Midges												
Tendipedidae	22	3	5	–	–	-	6	48	276	360	384	456
Brackish Water Clams												
Pelecypoda	–	–	–	–	–	–	–	–	–	24	24	–
Brackish Water Sow Bugs												
Isopoda	–	–	–	–	–	–	–	–	–	–	–	24
Brackish Water Worms												
Polychaeta	–	–	–	–	–	–	–	–	–	–	–	168
POLLUTION-TOLERANT ORGANISMS												
Bloodworms												
Tendipes	–	5	10	–	–	–	13	32	16	24	–	–
Rat-Tailed Maggots												
Eristalis	–	–	–	–	–	–	–	–	–	24	–	–
Sludgeworms												
Tubificidae	3	400	203	74	48	614	640	1120	192	192	432	572
Total Organisms	40	409	218	74	48	614	659	1208	492	624	840	1220
Number of Kinds	8	4	3	1	1	1	3	5	5	5	3	4

* = The letters W, C, and E, denote samples obtained from west side, navigational channel, and east side of river bottom.
Q = Organisms not collected quantitatively, arbitrarily given a value of one in totals.

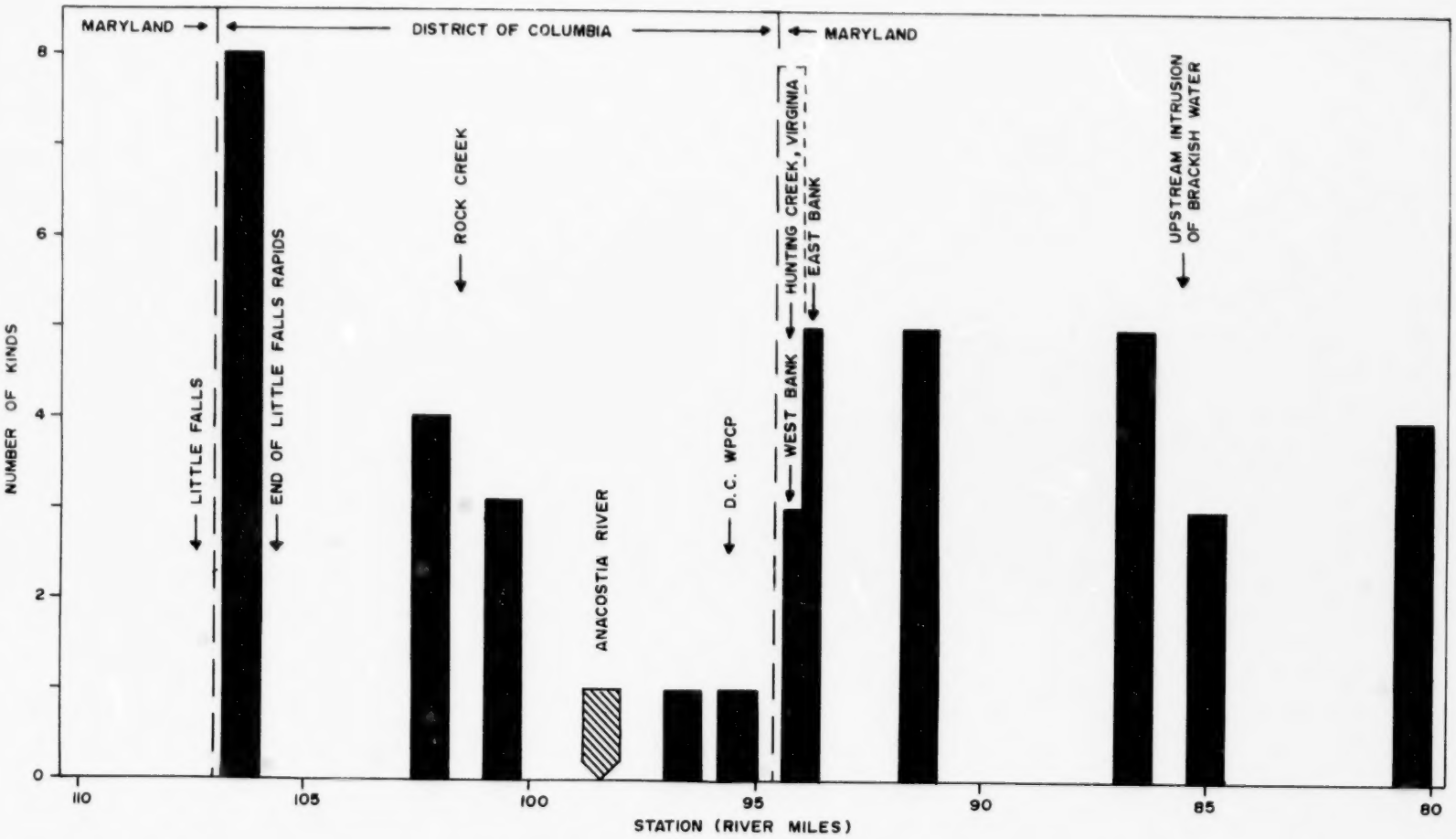


FIGURE 13 NUMBER OF KINDS OF BOTTOM ANIMALS, POTOMAC RIVER AND ANACOSTIA RIVER, MARYLAND, DISTRICT OF COLUMBIA AND VIRGINIA, 1965 & 1967

Table 16

Number of Bottom Animals Per Square Foot, Rock Creek
Maryland and Washington, D. C.
August 1966

Station (River Mile)	101.9-26.0	101.9-23.1	101.9-14.9	101.9-11.1	101.9-3.9	101.9-2.4	101.9-1.2	101.9-0.1
POLLUTION-SENSITIVE ORGANISMS								
Stoneflies								
Paragnetina	Q	–	–	–	–	–	–	–
Mayflies								
Ameletus	3	–	–	–	–	–	–	–
Stenonema	9	Q	–	–	–	–	–	–
Isonchia	8	–	–	–	–	–	–	–
Baetis	–	–	15	–	–	–	–	–
Heptagenia	–	–	1	4	–	–	–	–
Fishflies								
Chauliodes	4	3	–	–	–	–	–	–
Alderflies								
Sialis	2	–	–	–	–	–	–	–
Caddisflies								
Neophylax	–	Q	12	–	–	–	–	–
Hydropsyche	34	3	3	–	–	2	–	–
Chimarra	1	–	–	–	–	–	–	–
Riffle Beetles								
Stenelmis	15	1	–	–	–	–	–	–
Subtotal	77	9	31	4	0	2	0	0
Subtotal Kinds	9	5	4	1	0	1	0	0
INTERMEDIATE ORGANISMS								
Crawling Water Beetles								
Haliplidae	–	–	–	–	1	–	–	–
Whirlygig Beetles								
Gyrinidae	–	Q	–	–	–	–	–	–
Scavenger Beetles								
Hydrophylidae	1	–	–	–	–	–	–	–
Snipe Flies								
Atherix	19	–	–	–	–	–	–	–
Crane Flies								
Antocha	1	–	–	–	–	–	–	–
Shoreflies								
Ephydra	1	–	–	–	–	–	–	16
Black Flies								
Simulidae	–	–	Q	3	–	Q	–	–
Snails								
Physa	–	Q	Q	Q	Q	Q	3	–
Limpets								
Ferrissia	–	Q	Q	Q	Q	Q	–	–
Fingernail Clams								
Sphaerium	–	15	–	–	–	—	–	–
Roundworms								
Nematoda	–	–	–	2	–	–	–	–
Midges								
Tendipedidae	7	11	190	13	20	46	390	128
Aquatic Earthworms								
Lumbriculidae	–	Q	–	1	1	–	–	–
Leeches								
Hirudinea	–	–	–	–	3	–	–	–
Subtotal	29	30	193	21	27	49	393	144
Subtotal Kinds	5	6	4	6	6	4	2	2
POLLUTION-TOLERANT ORGANISMS								
Bloodworms								
Tendipes	–	–	Q	Q	–	Q	16	–
Sludgeworms								
Tubificidae	3	Q	3	–	–	5	71	768
Sewage Flies								
Psychoda	–	–	–	–	–	–	–	16
Subtotal	3	1	4	1	0	6	87	784
Subtotal Kinds	1	1	2	1	0	2	2	2
Grand Total	109	40	228	26	27	57	480	928
Number of Kinds	15	12	10	8	6	7	4	4

Q = Organisms not collected quantitatively, arbitrarily given a value of one in totals.
* = Samples on February 8, 1967.

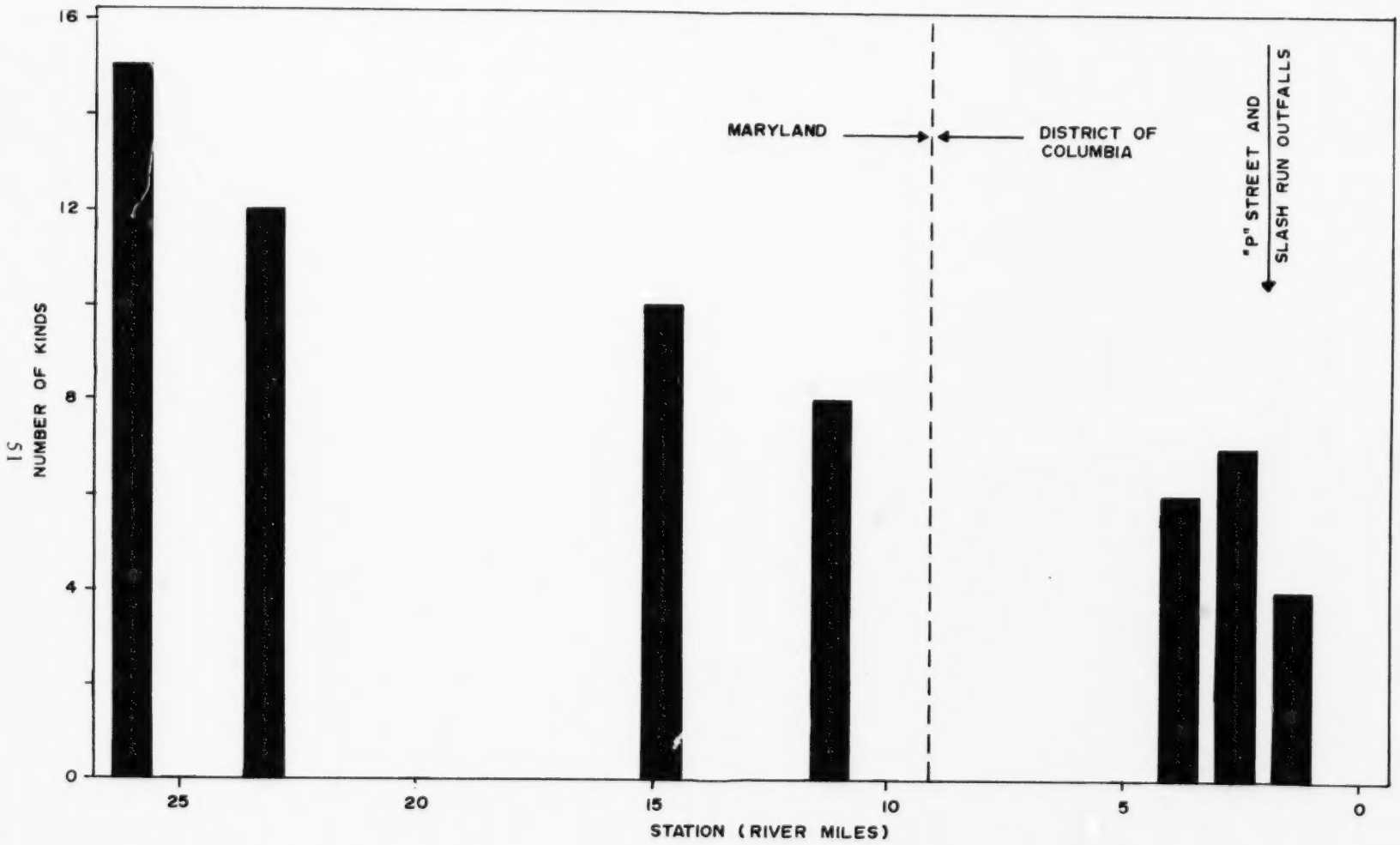


FIGURE 14 NUMBER OF KINDS OF BOTTOM ANIMALS, ROCK CREEK, MARYLAND, AND DISTRICT OF COLUMBIA, AUGUST, 1966

Table 17

Potomac River Water Turbidity

(Jackson Candle Units)

STATION LOCATION	Above Williamsport, Maryland	At Great Falls	Arlington Memorial Bridge	Hallowing Point
Reference to D.C. Metropolitan Area	**ABOVE**	**ENTERING**	**WITHIN**	**BELOW**
River Mile	212.5	125.6	100.7	80.7
SEVEN SUMMER SEASONS OF LOW RIVER FLOW	(From Potomac River Water Quality Network)			
(July, Aug. and Sept. during 1960-1966 Water Years)				
Seasonal Average	12	27	37	54
Minimum Monthly Average	1	10	23	30
Maximum Monthly Average	96	67	113	89
Number of months of data	19	14	21	21
1965 WATER YEAR	(From U. S. Dept. of the Interior, FWPCA, Water Pollution Surveillance System Data)			
Mean Value	40	61	75	-
Minimum Value	25	25	23	-
Maximum Value	250	900	700	-
Number of Samples	46	52	52	0

were found east of Rockville, and 26 per square foot with only one clean water form were found near the District line. Near its mouth there were four kinds of organisms dominated by 784 sludgeworms per square foot.

The Anacostia River, 1.3 miles upstream from its mouth, supported only 74 sludgeworms per square foot. This very small number of this very pollution-tolerant organism indicated the possibility of some undetermined type of toxicity in this reach of the Anacostia, oily, oozy sludge deposits were five inches deep.

Bottom Sludges

Core samples of bottom materials revealed no slimes, oils or offensive odors in the Potomac in the vicinity of Little Falls. At Key Bridge, however, there were intermittent patches of four to six inch thick dark gray, sludge-like ooze that was covered by an inch of light brown flocculent solids.

Between Arlington Memorial Bridge and Twin Highway Bridges, there were 14 inches of compact light gray silt, covered by three inches of dark gray ooze and one inch of light brown, flocculent solids. Oil and a sewage-like odor occurred in the upper four inches of these deposits.

Just downstream from the D.C. plant, bottom deposits had a sewage odor, and contained oil, gritty vegetable matter, seeds, and scraps of paper and plastics. The deposits consisted of 13 inches of compacted, laminated sediments overlaid with 10 inches of dark black sediment and one half inch of light brown floc.

About four miles downstream from the plant there were three inches of sludge. There were about 14 inches of sludge in the mouth of Four Mile Creek, 10 inches in the bay at the mouth of Hunting Creek, and six inches in the Anacostia River.

The sludgeworm population that occurred throughout much of the Potomac estuary from Key Bridge to Hallowing Point attested to the existence of organic deposits in much of this reach of the estuary. This conclusion is supported by the excessive oxygen demand of bottom deposits in much of the reach, as discussed earlier.

The total phosphorus (P) content of the sludges ranged from 0.11 to 0.27 percent of the dry weight of the sludge;the maximum occurred in the bottom deposits in the vicinity of the D.C. plant. This phosphorus contributes to nourishment of the excessive algae of the estuary. Even after control of phosphorus in the river is achieved by adequate treatment of wastes, the phosphorus in the sludge may continue to contribute to excessive algal growths for several years, especially when sediments become resuspended in the water through turbulence.

Sludge deposits were not measured in Rock Creek, but oil, scum, slimes and foul odors occurred in bottom materials below the outfalls of the P Street combined sewer and the Slash Run interceptor in the District. Oil, sewage-like odors, sewage bacteria, brownish algal slimes and stalked protozoa, all characteristic of sewage pollution were reported near the mouth of the creek.

TURBIDITY

Available data on turbidity are shown in Table 17. At Great Falls, turbidity averaged 61 units for the year 1965. It was as low as 25 units at times, but reached a maximum of 900 units during an intense storm.

Data in Table 17 also show average monthly turbidity levels during the three recreational months (July, August, and September) 1960 through 1966. The seasonal averages for the seven years increased from 12 units at Williamsport, Maryland, in the rural area 100 miles above Washington, to 27 units at Great Falls, just upstream from the entrance of the Potomac to the estuary. The seasonal average increased to 37 units at Arlington Memorial Bridge and to 54 units at Hallowing Point. The maximum monthly average during the period was 113 units at Arlington Memorial Bridge.

Turbidity is determined by measuring interference with passage of light through water. Although related to silt content, turbidity is not directly proportional to silt. This method of determination also measures the light interference by other suspended matter, such as algae and suspended solids from sewage. Algae and suspended solids undoubtedly account for at least some of the increase in turbidity through the estuary.

In their October 1957 report, "A Clean Potomac River in the Washington Metropolitan Area," Wolman, Geyer and Pyatt stated "For people living in the Washington area, silt is the worst pollutant of the Potomac River." They estimated that "the annual silt load of 60,000,000 cubic feet spread evenly to the water surface would completely fill the tidal Potomac from Chain Bridge to Fort Foote below Alexandria in 50 years."

Despite the considerable investments in pollution control measures that already have been made in the Washington Metropolitan Area, it is obvious that additional corrective measures are urgently needed.

Bacteria must be reduced to a very small percentage of present quantities to meet established standards and protect the health of all who come in contact with the water.

Oxygen demand must be reduced to improve DO to meet standards that will ensure propagation of desirable fish and other aquatic life, and will prevent odor nuisance.

Phosphorus must be reduced to control excessive algae and aquatic plant growths with their accompanying nuisances.

Sewage-associated suspended solids must be reduced to prevent sludge deposits that interfere with desirable bottom organisms and use needed DO.

Silt must be controlled to reduce filling of the estuary in the metropolitan area, to improve the appearance of the water and conditions for fish and other desirable aquatic life, and to ensure more desirable bathing areas.

Debris must be controlled to improve the appearance and aesthetic appeal of the river.

BACTERIA

The Maryland standard for fecal coliform bacteria requires that the average MPN density of these bacteria not exceed 240 per 100 ml at and below the District of Columbia-Maryland line.

Data on total and fecal coliform bacteria in the raw sewage of the District of Columbia, Arlington, Alexandria and Fairfax Westgate plants during February 1967, are shown in Table 18. These data were combined with average annual flows from the treatment plants (Table IV - Appendix) to calculate the permissible number of fecal coliform bacteria from each plant that would ensure adherence to the standard at the specified minimum flow of the Potomac River (7-day consecutive low flow once-in-10 years of 705 cfs).

At 1966 sewage plant flows, reduction of fecal coliform MPN densities to 42,000 per 100 ml or less in the effluents from the four plants will accomplish the necessary improvement. A reduction of about 98 percent in fecal coliform bacteria by all sewage treatment plants will be necessary. The reduction in fecal coliforms will be accompanied by a reduction in total coliforms to a calculated density, in all plant effluents, of 255,000 per 100 ml. This can be accomplished by adequate disinfection.

As sewage plant flows increase, a corresponding decrease in effluent coliform densities will be required to meet the standards.

The calculations made no allowance for bacteria from combined sewer overflows or bypassing of raw sewage. It is assumed that these sources of bacteria will be brought under adequate control, and no longer will contribute to pollution of the estuary.

The bacteria in Rock Creek and the Anacostia River appear to be from storm water runoff, combined sewer overflows, and bypassing of sewage and not from identifiable continuous sewage discharges, either raw or treated. These two small streams will be protected from bacterial pollution only by the same types of measures that are adopted for protection of the Potomac estuary against similar sources of bacteria.

OXYGEN DEMAND AND DISSOLVED OXYGEN

The Maryland stream standards require that the DO of the Potomac average not less than 5.0 mg/l and that minimum DO be not less than 4.0 mg/l. The design flow for this standard is the same as for bacteria, the 7-day consecutive low flow once in 10 years (705 cfs).

The PE of the treated wastes from all sewage treatment plants in the metropolitan area during 1967 totalled 674,000 or a total BOD_5 of 121,000 pounds per day. The BOD_5 data for the Potomac River during the low flow months of July, August and September 1965, which have been discussed earlier, are shown on Figure 8, and are listed in Table 19. The accompanying DO, also previously discussed, is shown in Figure 10, and also is listed in Table 19.

Additional data for July, August and September for the years 1960 through 1966 are presented in Table III of the Appendix. Of these, only the 1965 data were used for calculations because the stream flow for July, August and September of that year was low and reasonably uniform.

Table 18

BACTERIOLOGICAL DATA

District of Columbia Water Pollution Control Plant

Date	Time	Coliform	Fecal Coliform
2-2-67	1415	> 16,090,000	5,420,000
2-6-67	1250	16,090,000	5,420,000
2-13-67	1145	9,180,000	790,000
2-13-67	1500	17,200,000	700,000
2-14-67	1325	5,420,000	700,000
2-14-67	1540	17,200,000	2,300,000
2-15-67	0915	34,800,000	10,900,000
2-15-67	1225	17,200,000	4,600,000
Geometric Average		14,800,000	2,450,000

Arlington Sewage Treatment Plant

Date	Time	Coliform	Fecal Coliform
2-2-67	1140	2,400,000	790,000
2-3-67	1020	3,480,000	1,300,000
2-3-67	1310	5,420,000	1,300,000
2-6-67	1340	24,000,000	5,420,000
2-6-67	1455	16,090,000	16,090,000
2-13-67	1015	5,420,000	2,400,000
2-13-67	1330	2,400,000	2,400,000
2-14-67	1200	3,480,000	700,000
2-14-67	1415	9,400,000	2,100,000
2-15-67	1020	3,480,000	2,400,000
2-15-67	1310	3,480,000	3,480,000
Geometric Average		5,290,000	2,270,000

Table 18 (contd.)

BACTERIOLOGICAL DATA

Alexandria Sewage Treatment Plant

Date	Time	Coliform	Fecal Coliform
2-2-67	1215	5,420,000	490,000
2-3-67	1050	1,720,000	110,000
2-3-67	1340	9,180,000	5,420,000
2-6-67	1410	16,090,000	3,480,000
2-6-67	1525	17,200,000	2,400,000
2-13-67	1045	10,900,000	700,000
2-13-67	1400	16,090,000	1,720,000
2-14-67	1230	16,090,000	460,000
2-14-67	1445	10,900,000	800,000
2-15-67	1050	16,090,000	9,180,000
2-15-67	1340	9,180,000	3,480,000
Geometric Average		10,100,000	1,380,000

Fairfax Westgate Sewage Treatment Plant

Date	Time	Coliform	Fecal Coliform
2-2-67	1330	542,000	49,000
2-3-67	1120	< 2,000	< 2,000
2-3-67	1400	< 2,000	< 2,000
2-13-67	1110	< 20,000	< 20,000
2-13-67	1430	20,000	< 20,000
2-14-67	1250	< 20,000	< 20,000
2-14-67	1510	< 20,000	< 20,000
2-15-67	1115	500	< 200
2-15-67	1400	< 200	< 200

Table 19

POTOMAC ESTUARY

Oxygen Demand and Dissolved Oxygen – July, August, and September 1965

Station	River Mile	BOD_5, mg/l			D.O. mg/l		
		Max.	Avg.	Min.	Max.	Avg.	Min.
Fletcher's Boathouse	104.5	5.8	2.7	1.0	9.6	7.4	6.0
Three Sisters Islands	103.1	4.2	2.0	0.2	8.7	7.1	5.4
Roosevelt Island	101.6	5.6	1.9	0.4	7.5	5.5	3.2
Memorial Bridge	100.7	3.6	1.5	0.2	8.3	5.6	3.5
Twin Highway Bridges	99.7	4.2	2.5	0.6	9.1	5.8	3.5
Mid-Potomac Park	99.1	6.2	2.7	0.2	9.0	5.7	3.3
Hains Point	98.3	11.4	6.9	3.2	10.4	4.3	1.2
Giesboro Point	97.4	15.1	8.8	3.0	7.0	3.5	0.9
Above D.C. STP	96.1	14.4	9.1	2.0	7.5	3.3	1.1
Opposite D.C. STP	95.6	15.0	10.6	7.0	5.9	2.8	0.4
Below D.C. STP	95.3	14.7	9.7	2.6	6.0	2.9	0.7
Woodrow Wilson Bridge	94.4	14.6	9.9	4.8	5.3	3.0	1.2
Fort Foote	92.9	15.0	9.2	5.4	5.7	3.2	1.6
Fort Washington	89.0	13.6	7.3	2.4	6.6	3.8	1.5
Marshall Hall	85.0	10.4	6.9	3.6	8.4	5.4	3.4
Hallowing Point	80.7	7.2	5.6	3.8	8.3	6.8	5.1

In addition to the foregoing data, an upstream BOD_5 of 2.0 mg/1, the observed bottom oxygen demand (Figure 9), and a stream temperature of 29 degrees C. were assumed for calculations of the BOD_5 load that can be discharged to the estuary to maintain an average DO of 5 mg/1. Calculations were based on the assumption that discharges will continue at the present locations.

A general description of the method used to calculate the assimilative capacity of the estuary is included in the Appendix.

Initial calculations revealed that the existing bottom demands alone would reduce the DO below 5.0 mg/1 at low flows. Subsequent calculations assumed that the necessary additional treatment would reduce the bottom oxygen demand ultimately to the 1 gram per square meter per day rate that is typical of an unpolluted estuary.

These calculations based on present discharge locations indicated that the 5-day BOD of all wastes discharged in the metropolitan area must be reduced to less than 16,500 pounds per day from the existing 121,000 pounds per day, or an additional reduction of 86 percent. The overall reduction of BOD_5 required from the total raw sewage load is 96 percent. It was assumed during the calculations that an 85 percent reduction in nitrogenous BOD would simultaneously occur.

The calculated average DO of the Potomac estuary that would result from the reduced BOD load is shown in Figure 15. The residual oxygen demand from upstream would cause a reduction in the DO of the water entering the estuary to a 5.9 mg/1 near Arlington Memorial Bridge. This would be followed by an increase in DO to 6.2 mg/1 above the D.C. plant. The D.C. plant effluent would cause a drop in DO to 5.0 mg/1 below the plant, followed by recovery to 6.9 mg/1 in the vicinity of Fort Washington.

Here again, as in the case of bacteria, no allowance was made for BOD from combined sewer overflows, or bypassing of sewage. It is assumed that these sources will be brought under control by other means.

The additional reduction in BOD_5 would ensure the maintenance of the average 5.0 mg/1 DO standard. The frequency distribution of DO values in the critical reach of the river for July through September, 1960 through 1966, was determined and is plotted in Figure 16. There were several causes of the DO variations in the estuary during the years 1960 through 1966. One of the causes was the variations in treatment plant efficiencies. For example, monthly averages of BOD_5 removal by the District of Columbia Plant in 1966 varied from 13.5 to 74.3 percent, with an annual average of 56.6 percent. Other contributing factors included the bypassing of sewage and combined sewer overflows. The significance of controlling these causes is shown in Figure 16. If these same DO variations were to occur following the necessary remedial measures, the minimum standard of 4.0 mg/1 would be violated during 26 days, or 28 percent of the time during the period July through September. More consistent operation of waste treatment plants along with greater reductions in oxygen demand, and the elimination of sewage bypassing, and combined sewer overflows must be accomplished to reduce the DO variations.

PHOSPHORUS

The need to control phosphorus discharged to the Potomac estuary as a means of controlling excessive algal growths has been discussed previously. It has been concluded, based on observations in the estuary, that limiting the total phosphorus concentration in the stream to 0.1 mg/1 (as P) will limit algal growths to tolerable levels.

Total phosphorus was determined in the raw sewage of the four major systems. The relatively small quantity of other sources of sewage was estimated on the basis of a per capita contribution of 0.01 pounds of phosphorus per capita per day. Combination of the two sets of values gives an estimated total of 21,100 pounds of phosphorus in the raw sewage of the metropolitan area.

Phosphorus is removed from solution in water by both physical absorption on suspended matter, and by incorporation in the bodies of aquatic plants and animals. In both cases the end result is that the phosphorus ultimately settles to the bottom of the stream. Observations in the Potomac estuary indicate that these mechanisms may reduce the phosphorus concentration in water to 0.03 mg/1, but not below.

At the design river flow of 705 cfs, and based on the foregoing considerations and the present discharge location, it was calculated that discharge of phosphorus to the Potomac estuary in the metropolitan area must be limited to 740 pounds per day if excessive algal growths are to be avoided. Achieving this would necessitate 96.5 percent reduction in phosphorus of the raw sewage at all treatment plants.

Figure 15

POTOMAC RIVER ESTUARY
DISSOLVED OXYGEN FOR 96% BOD REMOVAL
vs
RIVER MILES

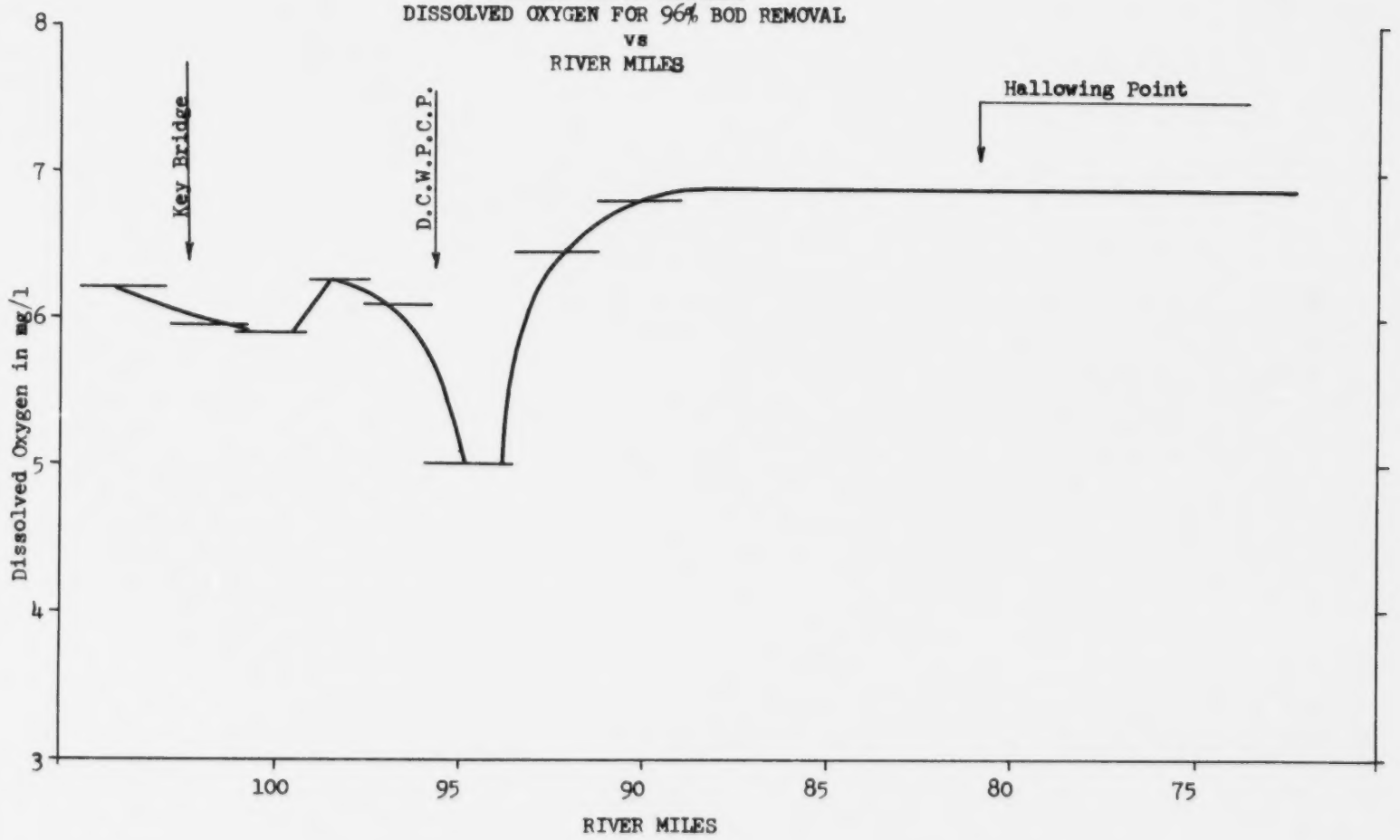


Figure 16

DISTRIBUTION OF VARIATION
IN D.O. AROUND MEAN VALUE
POTOMAC RIVER

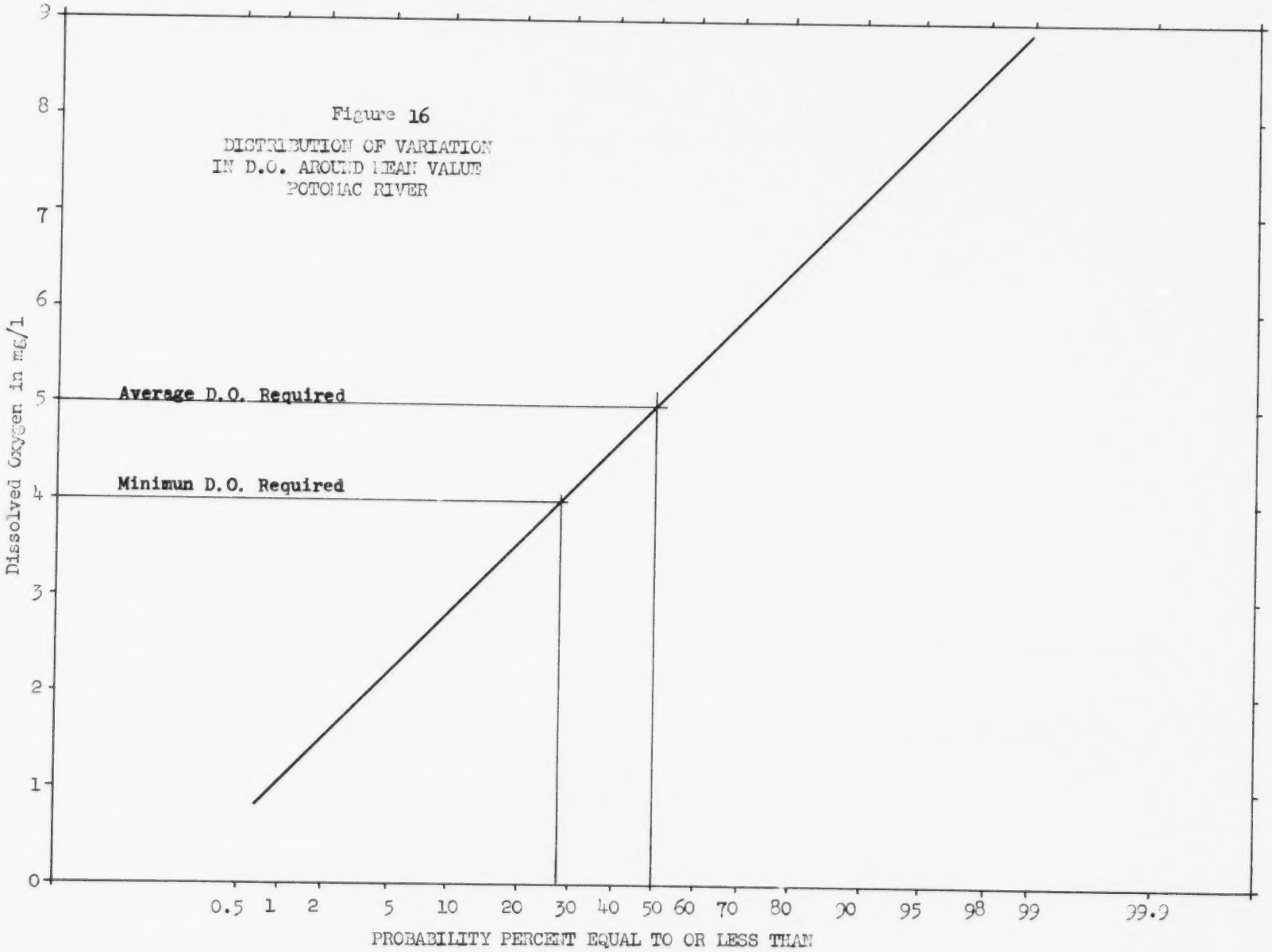
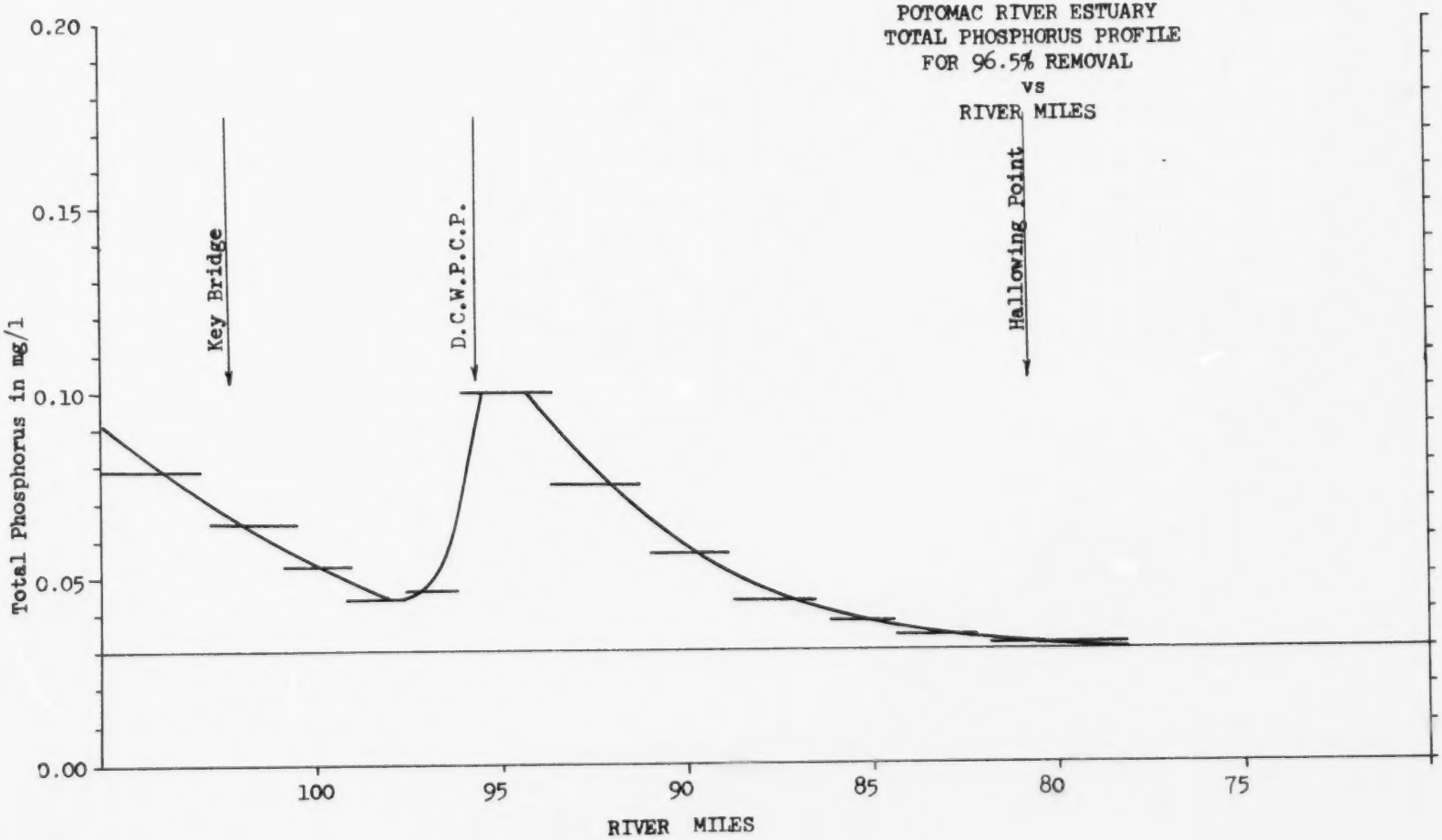


Figure 17

POTOMAC RIVER ESTUARY
TOTAL PHOSPHORUS PROFILE
FOR 96.5% REMOVAL
vs
RIVER MILES



The estimated phosphorus in the estuary following the recommended reduction is shown in Figure 17. The 0.09 mg/l of phosphorus entering the estuary from upstream would drop to 0.044 mg/l near Giesboro Point. A sharp rise in phosphorus to 0.10 mg/l would occur in the vicinity of the D.C. plant. This would be followed by a slow decline to the minimum level of 0.03 mg/l near Marshall Hall.

MULTIPLE DISPOSAL POINTS

The major effects of treated waste discharges peak at the outfall of the District of Columbia's plant. Calculations of waste assimilation capacity of the estuary (16,500 lb/day BOD_5), and BOD_5 and phosphorus removals (96 percent each) were based on the continued discharge by the District of Columbia's plant at the existing single outfall. Present technology can provide the degree of treatment needed by means of advanced waste treatment facilities requiring a consistent and highly efficient operation.

The high degree of treatment needed is based on maintaining the above-mentioned peak within the required limits at low flow conditions. Figures 15 and 17, based on concentrations in the estuary following the accomplishment of these high degrees of treatment indicate a recovery of the estuary in a relatively short distance (5-10 miles) downstream. An evaluation should be made of the feasibility of establishing multiple points along the estuary to discharge the District of Columbia Water Pollution Control Plant's wastes, rather than through the existing single discharge point. This evaluation should determine the possible advantages of such a measure to total estuarine water quality. Should this means prove feasible, such discharges can only follow the highest degree of treatment practicable, including phosphorus removal.

SLUDGE DEPOSITS

The sludge deposits should be effectively controlled by two prospective improvements in waste disposal. The recommended improvement in BOD removal by additional sewage treatment also will improve removal of the organic suspended solids that have been contributing to sludge deposits. Completion of the program for control of combined sewer discharges and of the bypassing of raw sewage will reduce the raw sewage solids that contributed to sludge deposits.

As discussed elsewhere, several years probably will elapse before existing sludge deposits stabilize and their effects on oxygen demand and on fish and aquatic life are reduced.

SILT

The successful control of silt cannot be accomplished by an individual locality acting independently. The widespread distribution of sources and of those responsible for the sources renders it imperative that a major cooperative effort be mounted if success is to be achieved.

Numerous municipal, county, state and interstate agencies and interested local associations presently conduct various soil erosion and sediment control programs. Municipal sewage treatment plants reduce the suspended solids content of waste waters. Soil conservation districts seek to keep the soil in place on the land. There are state and county laws and regulations designed to control erosion and promote recovery of strip mining areas.

Federal agencies are involved in soil conservation, management and restoration activities. The Department of Agriculture provides soil erosion control assistance on privately owned lands and in national forests. The National Park Service manages national monuments and the Fish and Wildlife Service provides Federal aid for wildlife restoration. The Bureau of Public Roads, working with the American Association of State Highway Officials, is preparing guidelines for improved highway construction practices to reduce erosion. The Corps of Engineers dredges navigation channels and provides storage space for sediment in reservoirs.

In their 1957 report, Wolman, Geyer and Pyatt recommended a large reservoir on the Potomac above Great Falls as a portion of a comprehensive sediment control program. The Corps of Engineers had proposed construction of the Seneca Reservoir, a multi-purpose project, above Great Falls, in their comprehensive program for development of water resources of the Potomac River Basin. This proposal met with much opposition, both private and official. The Secretary of the Interior's "Potomac Interim Report to the President" included in its recommendations "that Seneca Dam and Reservoir on the main stem of the Potomac not be constructed at this time, but that its site be preserved to the maximum feasible degree at its present level of economic development."

In addition to other programs already in progress, the "Report to Inter-Departmental Task Force on the Potomac by the Sedimentation and Erosion Sub-Task Force," May 1967, proposed an accelerated 10 yr. program for the control of erosion and sedimentation in the basin. The "Conclusions and Summary of Recommendations" of the Report are included in the Appendix. The recommended work consists of: surveys, planning and demonstration projects; highway construction controls and roadside stabilization; and technical assistance and construction of sediment control basins throughout the Potomac River Basin. The estimated costs are:

	Federal	Non-Federal	Total
Urban activities	$58,100,000	$5,990,000	$64,090,000
Rural and basin-wide activities	134,284,000	41,859,000	176,143,000
Strip mine reclamation	9,000,000	1,000,000	10,000,000
Total	$201,384,000	$48,849,000	$250,233,000

Of the total cost about one-third, $78,300,000 would be devoted to construction of sediment control basins. About two-thirds of this sum would be required in the most critical area of the Potomac basin, that in the vicinity of the District of Columbia.

The estimated reduction in silt reaching the streams of the basin that would be accomplished by the proposed program is:

Category	Percent of Total Silt
Basin-wide activities	6.5
Rural Controls	14.0
Urban Controls	24.0
Strip Mine Reclamation	3.0
Total	47.5

The total $250,000,000 cost of the program would accomplish much more than reduce the silt to the streams by almost one-half. An even greater benefit would result from the conservation of land and water resources and enhancement of land values in regions made more attractive by eliminating scars of erosion. Agricultural lands would be protected, wildlife habitats improved, and the pursuit of recreation would become more enjoyable and satisfying. Estuary dredging would be reduced.

RAW SEWAGE DISCHARGES

The District of Columbia's long-term program for control of raw sewage discharges from combined sewers and overloaded sewers already has been discussed. Commendable progress has been made, and a major portion of the program is scheduled for completion by 1969. Only the separation of sanitary and storm sewers that account for an estimated 22 percent of the raw sewage discharge will remain. Completion of this phase of the program is scheduled for the year 2000. This program should be continued and final completion date advanced: or other means of removing these raw sewage discharges accomplished.

AESTHETIC VALUES

Completion of projects already underway or recommended in this report will result in reduction of significant quantities of the repulsive sewage solids that intermittently litter the surface of the Potomac River estuary.

As long as storm sewers and surface runoff discharge to the Potomac, debris from natural and urban sources still will reach the estuary. Implementation of the recommended silt control program would accomplish some reduction in the debris from natural and urban sources, but would not eliminate it. A regular program of policing and removing such residual debris will be necessary for full protection of the scenic beauty of the Potomac.

"Operation Clean Waters," a cooperative effort of the Government of the District of Columbia and the Federal governemnt, utilizes enrollees of the Neighborhood Youth Corps to remove debris littering the banks of the Potomac and Anacostia Rivers and Rock Creek. Removing the material and debris contributes to the aesthetic value and reduces water pollution and safety hazards.

* * * * * * *

APPENDIX

Table I-A

POTOMAC RIVER IN THE WASHINGTON D. C. METROPOLITAN AREA

Potomac River WATER QUALITY STANDARDS

Zone	State	Uses	Criteria Bact.	D.O.	Temp.	pH
Main Stem in Montgomery (Md.) County (to D.C. line)	Maryland	Public or municipal water supply	A-3	B-3	C-3	D-1
		Water contact recreation	A-4			
		Propagation of fish, other aquatic life and wildlife				
		Agricultural water supply				
		Industrial water supply				
D.C.–Montgomery (Md.) County line to Key Bridge	D.C.[1/]	Fish and wildlife propagation	A-1	B-1	C-1	D-1
		Recreational boating				
		Industrial water supply				
		Water contact recreation				
Key Bridge to D.C.–Prince Georges (Md.) County line	D.C.[1/]	Maintenance of fish life	—	B-2	C-1	D-1
		Recreational boating				
		Industrial water supply				
D.C. line to Upper Cedar Point	Maryland	Water contact recreation	A-4	B-3	C-3	D-1
		Propagation of fish, other aquatic life and wildlife				
		Industrial water supply				
Rock Creek						
Headwaters to Detention Dam #5	Maryland	Water contact recreation	A-4	B-3	C-3	D-1
		Propagation of fish, other aquatic life and wildlife				
		Agricultural water supply				

Table I-A (Cont.)

Zone	State	Uses	Criteria Bact.	D.O.	Temp.	pH
Rock Creek (Cont'd.)						
Detention Dam # 5 to Norbeck Rd. (Rt. #28)	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife (trout) Agricultural water supply	A-4	B-3	C-3	D-1
Upstream of Dam #1	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife (trout) Agricultural water supply	A-4	B-3	C-3	D-1
Norbeck Rd. (Rt. #28) to D.C.–Montgomery (Md.) County line	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife	A-4	B-3	C-3	D-1
D.C.–Montgomery (Md.) County line to Potomac River	D.C.[1/]	Fish and wildlife propagation Wading (additional criteria*)	A-2	B-1	C-2	D-1
* Turbidity – Creek bottom visible in wading areas.						
Anacostia River						
Confluence of Northeast and Northwest Branches to D.C. line	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife Industrial water supply	A-4	B-3	C-3	D-1

Table I-A (Cont.)

Zone	State	Uses	Criteria Bact.	D.O.	Temp.	pH
Anacostia River (Cont'd.)						
D.C.–Prince Georges (Md.) County line to Potomac confluence	D.C.[1/]	Maintenance of fish life Recreational boating Industrial water supply	—	B-2	C-1	D-1
Oxon Run						
Maryland sections to mouth	Maryland	Water contact recreation Propagation of fish, other aquatic life and wildlife	A-4	B-3	C-3	D-1
D.C. line at Mississippi Ave., S.E. to D.C. line in vicinity of Nichols Ave., S.W.	D.C.[1/]	Fish and wildlife propagation	—	B-2	C-1	D-1

1/ The Secretary of the Interior excepted the dissolved oxygen and temperature criteria proposed in the District's water quality standards and recommended an early addition to the District's bacteriological water quality standards. Further, to better protect secondary contact recreation water uses (such as fishing and boating), appropriate bacteriological criteria should be adopted for the Potomac River below Key Bridge and the Anacostia River.

Table II-A

Code	Criteria
A-1	Fecal Coliform – Not to exceed 240/100 ml. in 90% of the samples collected each month.
A-2	Fecal Coliform – No. .o exceed 200/100 ml.
A-3	Public or Municipal Water Supply Uses – Monthly average value (either MPN or MF count) of **coliform organisms** not to exceed 5,000 per 100 ml. of sample; nor to exceed this number in more than 20% of the samples examined during any month; nor exceed 20,000 per 100 ml. in more than 5% of such samples. There must be no discharges of sewage, industrial waste or other waste that deleteriously affect the safety of the water supply and which could, in this manner, contravene the latest edition of the PUBLIC HEALTH SERVICE DRINKING STANDARDS (published by U.S. Public Health Service).
A-4	Water Contact Recreation Uses – The bacterial quality of water is acceptable for these uses when a sanitary survey reveals no source of dangerous pollution and when the fecal coliform organism density does not exceed 240 MPN per 100 ml. When the fecal coliform organism density exceeds 240 MPN per 100 ml., the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters.
B-1	Dissolved Oxygen – Not less than 4 mg/l.
B-2	Dissolved Oxygen – Not less than 3 mg/l.
B-3	For "trout waters," waters so designated to the Department by the Department of Game and Inland Fish, the dissolved oxygen concentration must not be less than 5.0 mg. per liter at any time, with a minimum monthly average of not less than 6.0 mg. per liter. For the propagation of fish and other aquatic life (Water Use Category IV) in all other waters, the dissolved oxygen concentration must not be less than 4.0 mg. per liter at any time, with a minimum monthly average of not less than 5.0 mg. per liter, except where–and to the extent that–lower values occur naturally. Any deviation, other than natural, from the above requirements is to be evaluated for risk to the propagation of fish and other aquatic life by the Department of Game and Inland Fish for nontidal waters, and by the Department of Chesapeake Bay Affairs for tidal waters, and will be permitted or denied by the Department of Water Resources after consultation with the aforementioned agencies.
C-1	Temperature – Not to exceed 93°F. There shall be no sudden or localized temperature changes that may adversely affect aquatic life.
C-2	Temperature – Not to exceed natural conditions.

Table II-A (Cont.)

Code	Criteria
C-3	FOR NONTIDAL WATERS: For "trout waters," waters so designated to the Department by the Department of Game and Inland Fish, temperature must not exceed 72°F. at any time. For the propagation of fish and other aquatic life (Water Use Category IV) in all other nontidal waters, temperature must not exceed 93°F. beyond such distance from any point of discharge as specified by the Department as necessary for the protection of the water use. In addition for all nontidal waters other than "trout waters," maximum temperature elevation is to be limited as follows: For natural water temperatures of 50°F., or less, the temperature elevation must not exceed 20°F. above the natural water temperature, with a maximum temperature of 60°F. For natural water temperatures greater than 50°F., the temperature elevation must not exceed 10°F. above the natural water temperature, with a maximum temperature of 93°F. Any deviation, other than natural, from the above requirements is to be evaluated for risk to the propagation of fish and other aquatic life by the Department of Game and Inland Fish, and will be permitted or denied by the Department of Water Resources after consultation with that agency. FOR TIDAL WATERS used for the propagation of fish and other aquatic life (Water Use Category IV), temperature must not exceed 90°F. beyond such distance from any point of discharge as specified by the Department as necessary for the protection of the water use. In addition, for all tidal waters, maximum temperature elevation is to be limited as follows: For natural water temperatures of 50°F., or less, the temperature elevation must not exceed 20°F. above the natural water temperature, with a maximum temperature of 60°F. For natural water temperature greater than 50°F., the temperature elevation must not exceed 10°F. above the natural water temperature, with a maximum temperature of 90°F. Any deviation, other than natural, from the above requirements is to be evaluated for risk to the propagation of fish and other aquatic life by the Department of Chesapeake Bay Affairs, and will be permitted or denied by the Department of Water Resources after consultation with that agency.
D-1	pH 6.0 - 8.5

Table III-A

POTOMAC RIVER

Data Summary for
July, August, and September

1960 - 1966

YEAR	Temp. °C.	5-day BOD mg/l	D.O. mg/l	Total Coliform MPN/100ml Geom.	Total Coliform MPN/100ml Arith.	Chlorides mg/l	Turbidity Units
Fletcher's Boat House (R.M. 104.5)							
1960	26.2	2.0	7.3	1,690	4,570	10	36
1961	28.0	2.2	7.5	530	1,470	16	33
1962	22.9	1.7	7.7	1,280	2,260	23	28
1963	25.1	1.8	7.2	1,760	9,410	21	44
1964	23.8	2.0	7.8	1,550	9,220	25	30
1965	26.5	2.7	7.4	1,690	4,230	26	36
1966	26.1	1.5	5.7	3,130	13,020	31	27
Three Sisters Islands (R.M. 103.1)							
1960	25.6	1.9	7.4	930	2,410	13	25
1961	28.2	2.0	7.8	625	1,070	17	25
1962	25.1	2.8	7.7	660	1,360	21	27
1963	25.0	1.7	6.6	3,290	16,900	21	58
1964	23.8	1.8	7.6	1,450	7,460	25	26
1965	26.3	2.0	7.1	2,150	4,410	26	42
1966	25.9	1.6	5.7	3,250	6,840	28	31
Roosevelt Island (R.M. 101.6)							
1960	25.4	1.9	7.1	5,740	14,240	11	27
1961	28.0	1.9	7.8	2,030	6,430	15	27
1962	25.0	2.2	7.6	2,620	6,300	23	28
1963	25.2	2.4	6.1	6,780	14,800	21	56
1964	23.9	2.9	6.5	19,900	79,150	22	34
1965	26.1	1.9	5.5	18,850	46,560	25	42
1966	25.8	3.3	4.6	44,000	160,000	30	36
Arlington Memorial Bridge (R.M. 100.7)							
1960	25.6	1.9	6.7	4,780	8,570	13	27
1961	28.0	2.2	7.5	2,480	9,660	16	31
1962	24.9	2.1	7.2	2,660	6,100	30	28
1963	25.2	1.6	5.9	4,800	25,340	21	58
1964	24.0	2.3	6.3	18,000	49,600	26	25
1965	26.2	1.5	5.6	11,860	18,660	25	41
1966	25.7	2.8	4.9	12,050	54,300	29	46

Table III-A (Cont.)

POTOMAC RIVER

Data Summary for
July, August, and September

1960 - 1966

YEAR	Temp. °C.	5-day BOD mg/l	D.O. mg/l	Total Coliform MPN/100ml Geom.	Total Coliform MPN/100ml Arith.	Chlorides mg/l	Turbidity Units
Fort Foote (R.M. 92.9)							
1960	26.0	3.7	4.1	11,700	68,050	12	33
1961	28.2	3.8	4.1	18,000	47,090	16	34
1962	25.0	5.7	2.5	39,600	41,400	27	32
1963	25.3	6.7	2.8	3,260	7,830	26	37
1964	24.8	8.2	2.5	43,000	187,400	27	37
1965	26.8	9.2	3.2	48,100	105,000	31	57
1966	26.2	10.0	3.0	189,000	282,000	37	52
Fort Washington (R.M. 89.0)							
1960	26.0	4.2	4.7	1,370	2,340	11	36
1961	27.8	4.6	4.6	2,900	9,680	16	38
1962	24.7	4.4	3.2	1,120	1,480	25	36
1963	25.1	6.5	4.0	670	1,470	34	47
1964	24.5	7.4	3.8	1,180	2,030	29	39
1965	26.6	7.3	3.8	3,750	5,860	35	60
1966	26.0	7.6	4.4	10,800	19,300	48	53
Marshall Hall (R.M. 85.0)							
1960	26.0	3.9	5.4	1,310	2,280	11	41
1961	27.6	4.6	5.8	1,320	2,110	17	41
1962	24.6	4.6	4.6	1,150	1,700	29	73
1963	24.9	6.0	6.1	300	1,770	85	49
1964	24.2	6.7	6.1	150	220	41	50
1965	25.9	6.9	5.4	220	760	57	52
1966	25.9	5.5	5.6	470	2,990	112	60
Hallowing Point (R.M. 80.7)							
1960	26.1	4.0	6.6	1,070	1,800	10	40
1961	27.4	4.8	6.9	252	2,770	18	47
1962	24.3	4.4	6.5	1,130	3,600	41	49
1963	24.6	6.9	7.5	380	5,470	199	64
1964	24.0	6.8	7.1	60	170	72	58
1965	25.9	5.6	6.8	140	950	93	60
1966	25.8	4.8	6.8	240	2,420	177	62

Table III-A (Cont.)

POTOMAC RIVER

Data Summary for
July, August, and September

1960 - 1966

YEAR	Temp. °C.	5-day BOD mg/l	D.O. mg/l	Total Coliform MPN/100ml Geom.	Total Coliform MPN/100ml Arith.	Chlorides mg/l	Turbidity Units
Above D.C. – W.P.C.P. (R.M. 96.1)							
1960	25.6	3.0	4.2	63,900	136,150	12	35
1961	28.4	4.6	4.5	75,700	143,750	16	38
1962	25.3	7.4	3.7	98,100	189,000	25	47
1963	25.3	6.7	2.8	32,500	61,000	24	107
1964	25.0	7.9	2.5	76,750	151,200	26	33
1965	26.8	9.1	3.3	521,000	2,971,000	29	61
1966	26.3	11.0	3.1	158,000	228,000	32	53
Opposite D.C. – W.P.C.P. (R.M. 95.6)							
1960	25.9	2.4	4.6	19,700	29,920	11	39
1961	28.5	3.9	4.9	79,400	152,000	16	46
1962	25.8	5.5	4.4	68,600	152,000	23	40
1963	25.7	6.8	2.8	22,600	51,750	25	56
1964	25.3	7.7	4.5	68,400	141,700	25	38
1965	26.9	10.6	2.8	130,000	366,910	29	64
1966	26.9	11.0	4.1	302,000	611,000	31	62
Below D.C. – W.P.C.P. (R.M. 95.3)							
1960	25.8	4.0	3.9	81,000	407,150	12	42
1961	28.4	4.8	4.7	217,000	703,000	17	35
1962	25.6	6.5	3.5	97,500	148,000	25	33
1963	25.4	6.6	2.6	31,100	53,100	25	45
1964	25.1	8.5	3.0	150,000	500,000	26	33
1965	26.8	9.7	2.9	118,000	217,640	31	60
1966	26.6	10.4	2.9	498,000	862,000	32	54
Woodrow Wilson Bridge (R.M. 94.4)							
1960	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-
1962	25.4	5.9	2.9	31,800	35,800	30	34
1963	25.4	6.6	2.6	52,200	78,440	27	48
1964	25.5	9.2	2.7	96,800	277,000	27	34
1965	26.6	9.9	3.0	50,700	99,730	30	55
1966	26.4	11.1	2.5	167,500	214,000	35	54

Table III-A (Cont.)

POTOMAC RIVER

Data Summary for
July, August, and September

1960 - 1966

YEAR	Temp. °C.	5-day BOD mg/l	D.O. mg/l	Total Coliform MPN/100ml Geom.	Total Coliform MPN/100ml Arith.	Chlorides mg/l	Turbidity Units
Twin Highway Bridge (R.M. 99.7)							
1960	25.6	1.9	6.8	4,000	6,910	14	29
1961	28.0	1.9	7.2	8,700	20,540	16	33
1962	24.9	1.9	6.9	4,230	9,000	23	29
1963	25.2	2.3	5.4	7,100	29,000	21	56
1964	23.9	2.2	5.6	13,500	34,900	23	33
1965	26.3	2.5	5.8	13,460	20,290	24	43
1966	25.7	3.0	5.6	11,100	84,100	27	53
Mid-Potomac Park (R.M. 99.1)							
1960	25.5	1.8	6.6	3,450	6,590	11	38
1961	28.0	2.3	7.5	4,150	12,040	14	35
1962	25.0	3.0	7.0	1,120	3,380	25	29
1963	25.3	3.2	5.5	4,960	25,540	22	54
1964	24.2	2.7	5.7	9,240	36,250	25	38
1965	26.3	2.7	5.7	3,600	5,090	26	46
1966	25.8	3.9	5.3	5,380	10,380	28	53
Hains Point (R.M. 98.3)							
1960	25.5	2.0	6.0	7,730	12,520	11	39
1961	28.1	3.1	7.3	3,550	9,790	14	36
1962	25.2	3.1	6.5	2,340	5,890	21	32
1963	25.5	4.4	4.0	9,950	46,040	20	51
1964	24.2	3.6	5.8	3,520	6,920	24	41
1965	26.5	6.9	4.3	20,900	100,280	28	73
1966	25.9	4.7	5.2	7,480	13,750	28	64
Giesboro Point (R.M. 97.4)							
1960	25.5	2.1	4.8	25,500	60,100	13	32
1961	28.1	3.0	5.4	24,100	95,900	16	40
1962	25.3	3.7	5.1	6,850	12,550	21	33
1963	25.5	5.5	3.3	26,200	64,240	23	48
1964	25.0	5.4	4.4	24,800	51,800	24	33
1965	26.6	8.8	3.5	113,300	232,750	28	52
1966	26.3	9.0	4.1	61,000	147,400	26	53

Table IV-A

Sewage Treatment Plant Operating Records for 1966 in the

Washington, D.C. Metropolitan Area

Month	Flow MGD	Arlington, Virginia					
		Suspended Solids			5-day BOD		
		Influent lb/day	Effluent lb/day	Efficiency %	Influent lb/day	Effluent lb/day	Efficiency %
December 1965	14.7	42,508	15,558	63.4	35,158	21,928	37.8
January 1966	15.3	44,115	15,428	64.9	39,780	25,372	36.0
February	19.4	45,267	17,783	60.7	45,913	32,333	30.0
March	17.1	43,605	17,242	60.5	46,882	33,488	29.0
April	17.8	51,768	18,690	63.8	44,055	29,963	32.3
May	18.2	53,842	18,048	66.2	42,467	27,300	35.8
June	17.6	44,880	16,133	64.4	36,080	23,907	33.7
July	17.2	46,440	15,767	66.1	38,557	24,080	37.6
August	16.8	45,360	15,400	66.1	36,120	21,420	40.7
September	17.4	46,110	16,385	64.6	31,465	19,430	38.3
October	17.7	43,808	15,782	64.0	31,565	19,470	38.6
November	16.2	49,815	16,605	66.7	34,965	19,845	43.2
Average for year	17.1	46,460	15,568	64.3	38,500	24,878	35.4

Table IV-A (Cont.)

Sewage Treatment Plant Operating Records for 1966 in the

Washington, D.C. Metropolitan Area

Month	Flow MGD	D.C. Water Pollution Control Plant					
		Suspended Solids			5-day BOD		
		Influent lb/day	Effluent lb/day	Efficiency %	Influent lb/day	Effluent lb/day	Efficiency %
January	191.5	204,267	156,392	23.4	244,162	154,796	36.6
February	215.4	224,375	165,140	26.4	253,095	218,990	13.5
March	201.0	216,075	97,150	55.0	252,925	95,475	62.2
April	214.1	276,546	114,187	58.7	262,272	110,618	57.8
May	222.5	222,500	81,583	63.3	254,021	94,562	62.8
June	231.4	250,633	75,205	70.0	273,823	102,202	62.7
July	232.9	232,900	60,166	74.2	223,196	133,918	40.0
August	233.1	238,928	112,665	52.8	250,582	108,780	56.6
September	231.9	260,888	65,705	74.8	262,820	67,638	74.3
October	216.0	257,400	66,600	74.1	262,800	72,000	72.6
November	206.5	246,079	72,275	70.6	270,171	73,996	72.6
December	209.2	226,633	73,220	67.7	244,067	90,653	62.8
Average for year	217.1	238,106	95,024	60.1	254,494	110,302	56.6

Table IV-A (Cont.)

Sewage Treatment Plant Operating Records for 1966 in the

Washington, D.C. Metropolitan Area

Month	Flow MGD	Alexandria, Virginia					
		Suspended Solids			5-day BOD		
		Influent lb/day	Effluent lb/day	Efficiency %	Influent lb/day	Effluent lb/day	Efficiency %
November 1965	12.0	27,940	5,470	80.4	21,500	4,680	78.2
December	12.3	35,110	6,340	82.0	29,630	6,260	78.9
January 1966	12.8	30,680	6,060	80.3	24,860	5,190	79.1
February	16.9	28,610	9,060	68.3	25,830	7,820	69.7
March	15.8	27,650	8,270	70.0	25,370	8,170	67.8
April	16.9	28,830	7,810	72.9	24,060	7,060	70.7
May	17.9	29,380	7,060	76.0	26,240	6,630	74.8
June	-	-	-	-	-	-	-
July	14.1	28,100	4,380	84.4	20,290	4,120	79.7
August	13.7	29,730	4,680	84.3	21,580	4,030	81.3
September	16.8	44,600	6,990	84.3	24,210	5,100	78.9
October	18.1	29,300	5,830	80.1	22,570	5,100	77.4
Average for year	15.2	30,903	6,541	78.4	24,194	5,833	76.0

Table IV-A (Cont.)

Sewage Treatment Plant Operating Record for 1966 in the

Washington, D.C. Metropolitan Area

Month	Flow MGD	Fairfax County, Virginia – Westgate Plant					
		Suspended Solids			5-day BOD		
		Influent lb/day	Effluent lb/day	Efficiency %	Influent lb/day	Effluent lb/day	Efficiency %
December 1965	9.8	21,245	9,560	55.0	24,094	12,288	49.0
January 1966	10.1	18,297	9,331	49.0	20,236	10,118	50.0
February	12.0	15,844	7,764	51.0	18,036	9,198	49.0
March	12.0	14,618	4,960	66.1	18,923	9,461	50.0
April	10.5	21,007	7,773	63.0	21,886	11,162	49.0
May	10.7	17,833	6,063	66.0	18,189	9,276	49.0
June	9.8	19,144	6,509	66.0	19,144	9,572	50.0
July	9.3	16,987	5,945	65.0	18,509	9,440	49.0
August	8.8	22,392	7,837	65.0	17,430	9,248	47.0
September	9.6	24,624	9,850	60.0	35,495	17,747	50.0
October	-	-	-	-	-	-	-
November	9.7	18,830	8,097	57.0	21,739	10,435	52.0
Average for year	10.2	19,166	7,608	60.3	21,244	10,722	49.5

THE POTOMAC RIVER ESTUARY MATHEMATICAL MODEL

The Potomac Estuary Mathematical Model was used to develop the dissolved oxygen and total phosphorus profile estimations shown in this report. The model, originally developed by the Delaware Estuary Comprehensive Project for the Delaware Estuary, was later adapted to the Potomac River Estuary by the Chesapeake Bay-Susquehanna River Project, FWPCA.

The computational procedure used in the model is based on the principles of systems analysis. The basic equation on which the model functions is that developed by Dr. D.J. O'Connor[1] for the case of a one-dimensional estuary.

To apply the model, the upper Potomac Estuary was divided into 21 segments of varying lengths and dimensions. Each segment was considered to have constant physical characteristics such as cross-sectional area, volume, and reaction coefficients. The various discharges of a waste constituent into each segment are measured or estimated and a final equation for the segment developed. When this procedure is completed, a series of equations result. For the Potomac Estuary, this consists of 21 equations with 21 unknowns, the unknowns being the concentration of the constituent sought. A high speed digital computer solves this series of equations and yields the average concentration in each segment. The final profile of the average constituent concentration can then be estimated by fitting a smooth curve through the consecutive segments.

It is to be emphasized that only average concentrations are estimated. The to-and-fro oscillations caused by tidal movement can cause significant variations from the mean value estimated. In fact, on the Potomac Estuary the dissolved oxygen has varied in the past in the order of ± 1 - 2 mg/1.

Further information on this model can be obtained from the Chesapeake Bay-Susquehanna River Project.

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(1)"Oxygen Balance of an Estuary," by D. J. O'Connor, *Transactions,* ASCE, Vol. 86, 1960.

INTERDEPARTMENTAL TASK FORCE ON THE POTOMAC
REPORT OF THE SUB-TASK FORCE ON SEDIMENTATION & EROSION MAY 1967

Conclusions and Summary of Recommendations

Land erosion and resulting stream pollution from sedimentation are among factors that recently focused national attention on the Potomac River Basin. Because of concern over this source of pollution, the Interdepartmental Task Force on the Potomac established the Sub Task Force on Sedimentation and Erosion. Accordingly, a working body representing a wide range of Federal, State, and local interests throughout the basin was established. This group was asked to examine in detail soil losses and stream sedimentation rates in the basin and to draw on appropriate principles of resource management for the development of a program to alleviate the erosion and sediment problem. This report describes erosion and sedimentation in the basin, weighs the relative significance of the various sources and proposes a 10-year program for dealing with the overall problem.

Although the Sub-Task Force recognizes that a basin-wide program is the most effective means of controlling the erosion and sediment problem in this report, it also identifies accelerated erosion resulting from urban development, highway construction, and strip mining as distinctive and concentrated sources of sediment which justify early corrective attention. As a result, nearly one-third of the recommended program deals with proposed support measures for controlling these more acute erosion and subsequent sedimentation problems. The Sub-Task Force particularly endorses continued development of new control techniques to deal effectively with these problems. The Sub-Task Force recommends the following measures to accelerate sediment and erosion control in the basin, without reference to priorities:

1. Initiate planning for additional small watershed programs throughout the Potomac Basin.
2. Control of erosion and sedimentation during highway and road construction.
3. Stabilization of road banks along secondary roads.
4. Completion and publication of soil surveys throughout the basin.
5. Economic evaluation of measures and facilitating techniques during the program installation period.
6. Physical evaluation and research of sedimentation and erosion control to provide guidelines for river basin developments in other areas.
7. Augmentation of technical assistance programs for establishment of conservation measures on cropland.
8. Expansion of the cost-sharing program to provide financial assistance for cropland conservation measures.
9. Sediment detention basins in rural areas below critical sediment sources.
10. Expanded technical assistance programs for establishment of conservation measures on pasture land.
11. Expansion of the cost-sharing program to provide added financial assistance for pasture conservation measures.
12. Expansion of the cost-sharing program to provide added financial assistance for forest conservation measures on privately owned land.
13. Acceleration of cooperative Federal-State forestry programs.
14. Increased funding of the "Development Program for the National Forests" within the basin.
15. Expansion of forest research programs relating to erosion control and the reduction of sediment.
16. Expansion of the program to provide technical assistance for erosion and sediment control practices in urban areas.
17. Demonstrations of erosion and sediment control measures in developing urban areas.
18. Sediment detention basins below critical sediment sources in urban and suburban areas.
19. Reclamation of areas damaged by strip mining.

It is the opinion of the Sub-Task Force that the successful completion of the program it proposes will effect a reduction in soil erosion in the basin and the resultant sediment contribution to the Potomac Estuary of about 48 percent.

The cost of the program is estimated at $250,233,000 with the Federal Government providing $201,384,000. This cost is for the acceleration of sediment and erosion control measures and is additional to present program levels.